IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

APPELLANTS:	Beck et al.	CONFIRMATION NO. 2868
SERIAL NO.:	10/725,299	GROUP ART UNIT: 2629
FILED:	December 1, 2003	EXAMINER: Jeffrey L. Piziali
TITLE:	OPERATING DEVICE FOR A DIAGNOSTIC IMAGING UNIT	

MAIL STOP APPEAL BRIEF-PATENTS
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPELLANT'S APPEAL BRIEF

S I R:

In accordance with the provisions of 37 C.F.R. §41.37, Appellants herewith submit their main brief in support of the appeal of the above-referenced application.

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Federal Cases

REAL PARTY IN INTEREST:

The real party in interest is the assignee of the application, Siemens Aktiengesellschaft, a German corporation.

RELATED APPEALS AND INTERFERENCES:

There are no related appeals and no related interferences.

STATUS OF CLAIMS:

Claims 2 and 10-14 are the subject of the present appeal, and constitute all pending claims of the application. Each of claims 2 and 10-14 stands as being finally rejected in the Office Action dated March 23, 2010.

Claims 1 and 3-9, which were previously pending in the application, are cancelled.

STATUS OF AMENDMENTS:

No Amendment was filed following the Final Rejection.

SUMMARY OF CLAIMED SUBJECT MATTER:

Independent claim 10 is the only independent claim of the application, and is set forth below with exemplary citations to the specification and drawings for all relevant claim limitations therein.

10. An operating device for a medical diagnostic imaging unit, said operating device comprising:

a display screen (touchscreen having a display area 20 and operating device 11 in Figs 2 and 3, p. 6, l. 11-12 and l. 21-22);

a control unit (operating device 11) configured to operate said display screen to display on said display screen one and only one at a time of a display area and an operating area (Figs. 2 and 3), that do not overlap

each other (areas 20 and 21 do not overlap), and a mode selection field (keys 23 in Figs 2 and 3; p. 7, l.3 - p.8, l.4) and also being configured to enter, in a current-value entering session, at least one examination value for implementing an examination by said medical diagnostic imaging unit;

said control unit being configured to operate said display screen, in said current-value entering session, in a programmed mode in which, in said operating area of the display screen, only a selection key field is displayed (selection keys 14, 15, 16 in Figs 2 and 3; p. 6, l. 16-20), said selection key field being activatable to select at least one preset value that is preset prior to said current value entering session (p. 7, l. 16-17), said at least one preset value being selected from the group consisting of preset operating values of said medical diagnostic imaging unit and preset parameter values of said medical diagnostic imaging unit (p.6, l . 21-23);

said control unit being also configured to operate said display screen , in said current-value entering session, in a manual mode (p.7, l.30 - p.8, l. 4) in which, in said operating area of said display screen, only a setting key field is displayed (setting keys 14, 15, 16 in Figs. 2 and 3; p.8, l. 24-26), said setting key field being activatable to selectively set at least one settable value selected from the group consisting of settable operating values of said medical diagnostic imaging unit and settable parameters of said medical diagnostic imaging unit (p.8, l.12-23);

said control unit being configured to display, in said display area in said current-value entering session, display elements (display elements 19 in Figs 2 and 3) respectively representing said at least one preset value and said at least one settable value (p.6, l. 11-18);

said control unit being configured to display at said display screen, in said current-value entering session, said mode selection field (switchover keys 23 in Figs 2 and 3), said mode selection field being activatable to select, as a selected mode, only one of either, said manual mode or said programmed mode (p.7, l. 30 - p.8, l.4);

said control unit being configured, in said current-value entering session, to initially maintain all of said display area unchanged and visually unobstructed with said at least one preset value or said at least one settable value displayed only once and only in said display area, when switching between said manual mode and said programmed mode by activation of said mode selection field, until said selection key field or said setting key field in the selected mode is activated after said switching (p. 9, l. 3-11); and

said control unit being configured to display, in said current-value entering session, at said display screen, a trigger key (recording key 24 in Figs. 2 and 3) that, when activated, emits a current content of said display area, as said at least one examination value, as an output available to said medical diagnostic imaging unit (p.7, l. 12-15 and p.9, l. 12-19).

Figs 1-3 of the application as originally filed are submitted herewith as Exhibit "A".

GROUND OF REJECTION TO BE REVIEWED ON APPEAL:

The sole issue to be reviewed on appeal is whether the subject matter of claims 2 and 10-14 would have been obvious to a person of ordinary skill in the field of designing operating systems for a medical examination apparatus, under the provisions of 35 U.S.C. §103(a) based on the teachings of United States Patent No. 6,795,528 (Nokita, Exhibit "B") in view of United States Patent No. 5,675,755 (Trueblood, Exhibit "C"), United States Patent No. 6,847,336 (Lemelson et al., Exhibit "D"), United States Patent No. 5,999,177 (Martinez, Exhibit "E"), United States Patent No. 6,983,331 (Mitchell et al., Exhibit "F"), and United States Patent No. 6,674,449 (Banks et al., Exhibit "G").

ARGUMENT:

Rejection of Claims 2 and 10-14 Under 35 U.S.C. §103(a) Based on Nokita, Trueblood, Lemelson et al, Martinez, Mitchell et al. and Banks et al.

In the Final Rejection dated March 23, 2010, in substantiating the above rejection, the Examiner stated that the Nokita reference discloses all of the limitations of independent claim 10, but acknowledged that the setting key field shown in Figure 8C of Nokita defers from the claimed invention insofar as the pop-up window does not completely overlap the operating area (Figure 8A; 840), and it overlaps some of the display area (Figure 8a, 830, 835, 825). The Examiner also acknowledged that the pop-up window disclosed in the Nokita reference displays the same parameter values (voltage, current, time and focal length) as were displayed in the display area, prior to the window popping-up and covering them.

The Examiner stated it would have been an obvious design choice to a person of ordinary skill in the art to move or re-size the pop-up window in the Nokita reference so that it would overlap the entire operating area, but not overlap any of

the display area, so as to provide the user with a clear view of all of the pertinent information on the entire left half of the screen, while simultaneously preventing the user from inadvertently pressing any of the operating area buttons. The Examiner stated such a repositioning of the pop-up window would reveal all of the parameter values in the display area, thereby eliminating any need for the pop-up window to display those values a second time. The Examiner also stated it would have been an obvious design choice to a person of ordinary skill in the art to remove duplicate data from being displayed, so as to save screen real estate, lower graphical processing demands, and present a less cluttered display image for the user.

The Examiner stated these modifications would have been obvious to a person of ordinary skill in the art because such a person would have "good reason" to pursue the known options within his or her technical grasp.

The Examiner relied on the Trueblood reference as disclosing a method for automatically preventing a pair of windows from overlapping each other. The Examiner relied on the Lemelson et al. reference as disclosing a graphical user interface for displaying x-ray images next to operating device parameter values.

The Examiner relied on the Martinez reference as disclosing a method for hiding display information that "serves no useful purpose" for the user.

The Examiner relied on the Mitchell et al. reference as disclosing a method for prioritizing sets or areas of display content and suppressing the display of some of that content when the available display space is determined to be too small.

The Examiner relied on the Banks et al. reference as disclosing a touch panel trigger key that causes a medical image to take a picture of a patient.

Appellants respectfully submit that the Examiner has used Appellants' disclosure as a roadmap through their prior art in order to suggest re-designing the display disclosed in the Nokita reference, and it is only by being "told" by Appellants' disclosure, as reflected in the claim language, that the explicit teaching in the Nokita reference to display respective values twice, and at two different locations, can be ignored and/or modified. It is important in the subject matter of claim 10 that when switching between the manual mode and the program mode, the value that is displayed at the display area is displayed only once and at only one location, i.e., in the display area. Even with the resizing of the display area of Nokita proposed by the Examiner in order to modify the operation of the Nokita reference, the respective values still would be displayed twice, and at two different locations.

This is even more relevant due to the further language in claim 10 that requires that, in the programmed mode, *only* a selection key field is displayed and, in the manual mode, *only* a setting key field is displayed. It is therefore not permissible for the Examiner to ignore the display area in Nokita, because this contradicts the requirement of claim 10 that only the aforementioned fields be displayed.

The Examiner is relying on the Lemelson et al. reference as providing a teaching of initially maintaining all of the display are unchanged and visually unobstructed, when switching between a manual mode and a programmed mode.

Appellants respectfully submit that even if such a teaching could be found in the Lemelson et al. reference, there is no basis to modify the Nokita reference by making use of such an alleged teaching. This is for the following reasons.

From Figures 8A and 8B of Nokita, it is clear that a number of parameters 835 (72 kV, 170 mA, 50 msec, 120 cm) are shown. In Figure 8C of Nokita, however, only 72 kV remains (at least partially) visible.

Therefore, Appellants submit that the Nokita reference does not disclose "maintaining *all* of said display area unchanged and visually unobstructed" as required in claim 10.

The Examiner has maintained the position that a resizing of the window in the foreground of Figure 8C would render all of the display area visible. Such a resizing was state of the art at the time of the present application, as disclosed in Lemelson et al. The Examiner uses this information as a basis for combining Nokita and Lemelson et al.

Appellants submit that the Nokita reference teaches away from employing such a resizing of the foreground window of Figure 8C. This is for the following reasons.

The aforementioned parameters 835 shown in Figures 8A and 8B are shown in Figure 8C at a different location, which is approximately in the center of the foreground window. If the window were resized according to the Examiner's suggestion, the set of parameters would be shown twice. Since it would be redundant to show the parameters a second time, this would not be a modification that a person of ordinary skill in the art would consider reasonable. Moreover, such a redundant display of the parameters would be confusing and detract from the user-friendliness of the display. A user does not expect information to be shown twice without any logical reason. Moreover, the user would not expect a background window to provide relevant information, because the user knows that the size of

display windows is changeable, and is therefore unlikely to pay much attention or attach importance to information shown in the background window. In addition to the redundancy, these factors would dissuade a person of ordinary skill in the art from undertaking the type of resizing proposed by the Examiner.

Additionally, resizing of the foreground window would cause additional information from the background window to be displayed that does not have significance in the current mode. This is because windows generally assume an oblong shape, and a resizing such that the entirety of the parameters 835 are still visible in the mode of Figure 8C would unavoidably result in additional information being shown from the background window that are not useful or needed in the current mode, and this would further detract from the user-friendliness. Those of ordinary skill in the field of designing computer displays operate on the premise that only relevant information should be shown at any given time. If the resizing were to reduce the height of the window, a setting key field (at the right side of Figures 8A and 8B) may even be visible in the mode of Figure 8C. This is also counter to the basis of the subject matter disclosed and claimed in the present application, which is for the purpose of providing a visually clear separation between setting keys and selection keys.

For these reasons, Appellants respectfully submit that the resizing proposed by the Examiner has occurred to the Examiner only as a way to "force" the Nokita/Lemelson et al. combination to allegedly conform to the subject matter of claim 10. It is not a practical or reasonable modification that would be considered by a person of ordinary skill in the art.

The Federal Circuit stated in *In re Lee* 227 F.3d 1338, 61 U.S.P.Q. 2d 1430 (Fed. Cir. 2002):

> "The factual inquiry whether to combine references must be thorough and searching. ...It must be based on objective evidence of record. This precedent has been reinforced in myriad decisions, and cannot be dispensed with."

Similarly, quoting *C.R. Bard, Inc. v. M3 Systems, Inc.*, 157 F.3d 1340, 1352, 48 U.S.P.Q. 2d 1225, 1232 (Fed. Cir. 1998), the Federal Circuit in *Brown & Williamson Tobacco Court v. Philip Morris, Inc.*, 229 F.3d 1120, 1124-1125, 56 U.S.P.Q. 2d 1456, 1459 (Fed. Cir. 2000) stated:

> [A] showing of a suggestion, teaching or motivation to combine the prior art references is an 'essential component of an obviousness holding'.

In *In re Dembiczak*, 175 F.3d 994,999, 50 U.S.P.Q. 2d 1614, 1617 (Fed. Cir. 1999) the Federal Circuit stated:

> Our case law makes clear that the best defense against the subtle but powerful attraction of a hindsight-based obviousness analysis is rigorous application of the requirement for a showing of the teaching or motivation to combine prior art references.

Consistently, in *In re Rouffet*, 149 F.3d 1350, 1359, 47 U.S.P.Q. 2d 1453, 1459 (Fed. Cir. 1998), the Federal Circuit stated:

> [E]ven when the level of skill in the art is high, the Board must identify specifically the principle, known to one of ordinary skill in the art, that suggests the claimed combination. In other words, the Board must explain the reasons one of ordinary skill in the art would have been motivated to select the references and to combine them to render the claimed invention obvious.

In *Winner International Royalty Corp. v. Wang*, 200 F.3d 1340, 1348-1349, 53 U.S.P.Q. 2d 1580, 1586 (Fed. Cir. 2000), the Federal Circuit stated:

> Although a reference need not expressly teach that the disclosure contained therein should be combined with another, ... the showing of

combinability, in whatever form, must nevertheless be clear and particular.

Lastly, in Crown Operations International, Ltd. v. Solutia, Inc., 289 F.3d 1367, 1376, 62 U.S.P.Q. 2d 1917 (Fed. Cir. 2002), the Federal Circuit stated:

> There must be a teaching or suggestion within the prior art, within the nature of the problem to be solved, or within the general knowledge of a person of ordinary skill in the field of the invention, to look to particular sources, to select particular elements, and to combine them as combined by the inventor.

Appellants submit that the decision of the United States Supreme Court in *KSR International Co. v. Teleflex Inc.*, 550 U.S. 398, 127 S.Ct. 1727, 82 USPQ 2d 1385 (2007), and the United States Patent and Trademark Office guidelines for applying that decision, support the position of the Appellants. That decision, although stating that it is not always required to point to a specific teaching in a prior art reference in order to substantiate a rejection under 35 U.S.C. §103(a), by no means approved ignoring the above long-standing precedent, and certainly did not represent a blanket overruling of that precedent. In the *KSR* decision, the Supreme Court stated, *under certain circumstances*, it may not be necessary to point to a specific passage in a prior art reference as evidence of motivation, guidance or inducement in order to modify that reference in a manner that obviates the patent claim in question. The Supreme Court stated that if a person of ordinary skill in the art can implement a *predictable variation* and would see the benefit of doing so, Section 103(a) likely bars patentability.

Nevertheless, the Supreme Court also stated that the requirement to find a teaching, suggestion or motivation in the prior art "captures a helpful insight." The Supreme Court stated that although common sense directs caution as to a patent

application claiming as innovation the combination of two known devices according to their established functions, it can be important to identify a reason that would have prompted a person of ordinary skill in the art to combine the elements as the new invention does. The Supreme Court, however, stated that not every application requires such detailed reasoning. The Supreme Court stated that helpful insights need not become rigid and mandatory formulas. The Supreme Court only stated that if the requirement to find a teaching, suggestion or motivation is required in such a rigid, formulaic manner, it is then inconsistent with the precedence of the Supreme Court. In fact, the Supreme Court stated that since the "teaching, suggestion or motivation" test was devised, the Federal Circuit doubtless has applied it in accord with these principles in many cases. The Supreme Court stated there is no necessary inconsistency between this test and an analysis conducted under the standards of *Graham v. Deere*. The Supreme Court stated the only error is transforming this general principle into a "rigid rule limiting the obviousness inquiry."

Therefore, Appellants submit this decision of the Supreme Court does not in any manner approve, much less require, the absence of a rigorous evidentiary investigation on the part of the Examiner in order to substantiate most rejections under 35 U.S.C. §103(a). Only under the somewhat unusual, and very limited, circumstances outlined by the Supreme Court in the *KSR* decision might the Supreme Court excuse the absence of such a rigorous evidentiary investigation in reaching a conclusion of obviousness under 35 U.S.C. §103(a).

This view of the *KSR* decision has been substantiated by the United States Court of Appeals for the Federal Circuit in *Takeda Chemical Industries Limited v. Alphapharm Pty.Ltd.*,492 F.3d 1350, 83 U.S.P.Q.2d, 169 (Fed. Cir. 2007), which was

one of the earliest decisions of the Federal Circuit after the *KSR* decision was decided by the Supreme Court. The *Takeda* decision concerned a chemical patent that was the subject of an infringement lawsuit, and which was attacked by the infringer on the basis of the claimed subject matter being "obvious to try." After acknowledging that the *KSR* decision held that the teaching-suggestion-motivation test should not be applied rigidly, the Federal Circuit stated that the *KSR* decision actually recognized the value of that test in determining whether the prior art provided a *reason* for one of skill in the art to make the claimed combination. The Federal Circuit stated this is consistent with the Federal Circuit precedent in *In re Dillon*, 919 F.2d 688 (Fed. Cir. 1990) and in *In re Deuel*, 51 F.3d 1552 (Fed. Cir. 1995). The Federal Circuit stated that in cases involving new chemical compounds, it remains necessary to identify some reason that would have led a chemist to modify a known compound in a particular manner to establish *prima facie* obviousness of the new claimed compound. In the *Takeda* decision, the Federal Circuit stated:

> The *KSR* Court recognized that "[w]hen there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp," *KSR*, 127 S.Ct. at 1732. In such circumstances, "the fact that a combination was obvious to try might show that it would obvious under §103." *id.* that is not the case here. Rather than identify predictable solutions for antidiabetic treatment, the prior art disclosed a broad selection of compounds, any one of which could have been selected as a lead compound for further investigation.

For the above reasons, Appellants submit that the modification of Nokita in view of Lemelson et al. proposed by the Examiner would not have been obvious to a person of ordinary skill in the field of designing operating systems for medical examination installations, under the provisions of 35 U.S.C. §103(a). It is not

necessary to individually address the other secondary references relied upon by the Examiner, because it is the position of the Appellants that the Nokita/Lemelson et al. combination does not disclose or suggest the limitations of claim 10 against which that combination was applied, and therefore even if the Nokita/Lemelson et al. combination were further modified in accordance with any of the additional references relied upon by the Examiner, the subject matter of claim 10 still would not result.

The same arguments apply to dependent claims 2 and 11-14 that depend from claim 10. None of those claims would have been obvious to a person of ordinary skill in the field of designing operating systems for medical examination installations for the same reasons discussed above in connection with claim 10.

CONCLUSION:

For the above reasons, Appellants respectfully submit the Examiner is in error in law and in fact in rejecting claims 2 and 10-14 as being obvious under 35 U.S.C. §103(a) based on the teachings of the above-cited references. Reversal of that rejection is proper, and the same is respectfully requested.

This Appeal Brief is accompanied by electronic payment for the requisite fee in the amount of $540.00.

Submitted by,

Steven H. Noll (Reg. 28,982)

STEVEN H. NOLL
SCHIFF, HARDIN LLP, **CUSTOMER NO. 26574**
Patent Department
6600 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606
Telephone: 312/258-5790
Attorneys for Appellants

CLAIMS APPENDIX

2. The operating device as claimed in claim 10, wherein the operating device is designed as a touch-sensitive display screen.

10. An operating device for a medical diagnostic imaging unit, said operating device comprising:

a display screen;

a control unit configured to operate said display screen to display on said display screen one and only one at a time of a display area and an operating area, that do not overlap each other, and a mode selection field and also being configured to enter, in a current-value entering session, at least one examination value for implementing an examination by said medical diagnostic imaging unit;

said control unit being configured to operate said display screen, in said current-value entering session, in a programmed mode in which, in said operating area of the display screen, only a selection key field is displayed, said selection key field being activatable to select at least one preset value that is preset prior to said current value entering session, said at least one preset value being selected from the group consisting of preset operating values of said medical diagnostic imaging unit and preset parameter values of said medical diagnostic imaging unit;

said control unit being also configured to operate said display screen , in said current-value entering session, in a manual mode in which, in said operating area of said display screen, only a setting key field is

displayed, said setting key field being activatable to selectively set at least one settable value selected from the group consisting of settable operating values of said medical diagnostic imaging unit and settable parameters of said medical diagnostic imaging unit;

said control unit being configured to display, in said display area in said current-value entering session, display elements respectively representing said at least one preset value and said at least one settable value;

said control unit being configured to display at said display screen, in said current-value entering session, said mode selection field, said mode selection field being activatable to select, as a selected mode, only one of either, said manual mode or said programmed mode;

said control unit being configured, in said current-value entering session, to initially maintain all of said display area unchanged and visually unobstructed with said at least one preset value or said at least one settable value displayed only once and only in said display area, when switching between said manual mode and said programmed mode by activation of said mode selection field, until said selection key field or said setting key field in the selected mode is activated after said switching; and

said control unit being configured to display, in said current-value entering session, at said display screen, a trigger key that, when activated, emits a current content of said display area, as said at least one

examination value, as an output available to said medical diagnostic imaging unit.

11. The operating device as claimed in claim 10 wherein said control unit is configured to display said display elements as text elements.

12. The operating device as claimed in claim 10 wherein said control unit is configured to display said display elements as graphics elements.

13. The operating device as claimed in claim 10 wherein said control unit is configured to display said trigger key at said display screen in each of said manual mode and said programmed mode.

14. The operating device as claimed in claim 10 wherein said medical diagnostic imaging unit is an x-ray examination unit, and wherein said control unit is configured to display, in said selection key field in said programmed mode, a plurality of selection keys each associated with one anatomical x-ray examination in a plurality of anatomical x-ray examinations, each selection key allowing a user to select said at least one preset value for the anatomical x-ray examination associated with that selection key, and to display, in said setting key field in said manual mode, a plurality of different setting keys that respectively allow manual setting of said at least one settable value for a component of said x-ray examination unit.

EVIDENCE APPENDIX

Exhibit A: Figs 1-3 as originally filed on December 1, 2003

Exhibit B: United States Patent No. 6,795,528 - cited in the March 23, 2010 Final Rejection

Exhibit C: United States Patent No. 5,675,755 - cited in the March 23, 2010 Final Rejection

Exhibit D: United States Patent No. 6,847,336 - cited in the March 23, 2010 Final Rejection

Exhibit E: United States Patent No. 5,999,177 - cited in the March 23, 2010 Final Rejection

Exhibit F: United States Patent No. 6,983,331 - cited in the March 23, 2010 Final Rejection

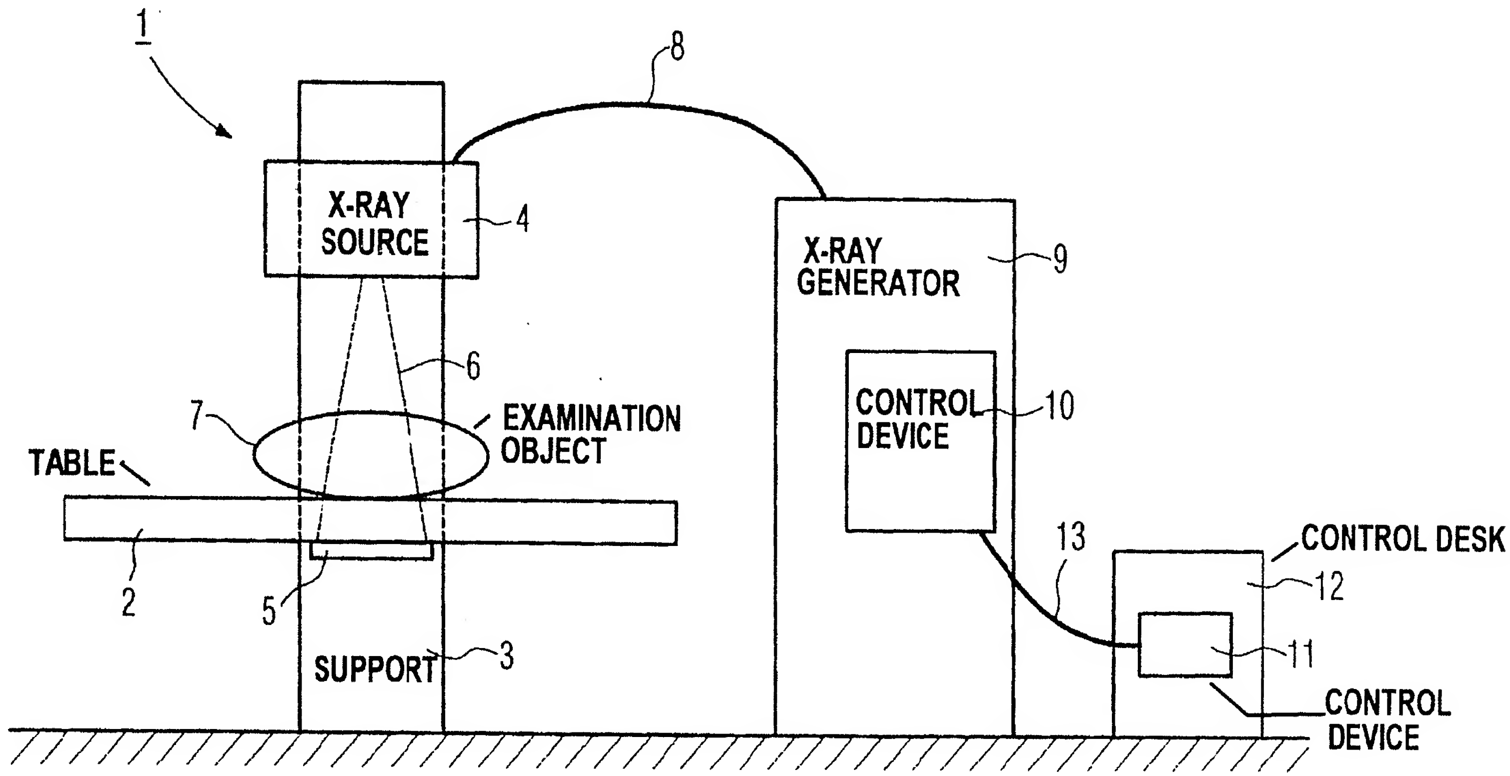
Exhibit G: United States Patent No. 6,674,449 - cited in the March 23, 2010 Final Rejection

RELATED PROCEEDINGS APPENDIX

None.

CH2\8817784.1

FIG 1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4
6
7
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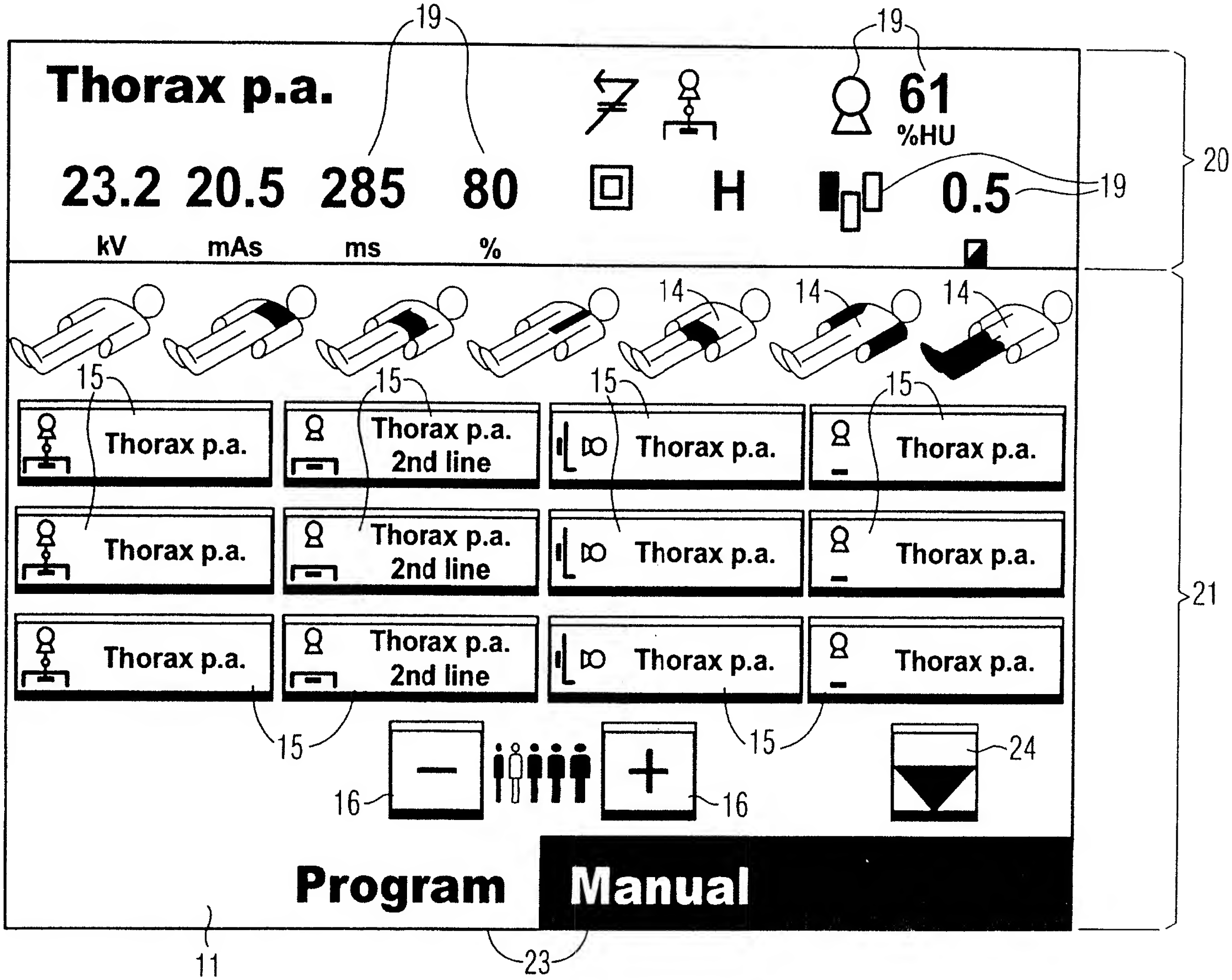
10
13
CONTROL DESK
12
11
CONTROL DEVICE

FIG 2



Thorax p.a.
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kV mAs ms %
61
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Thorax p.a.
Thorax p.a.
Thorax p.a.
Thorax p.a.
2nd line
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Thorax p.a.
Thorax p.a.
2nd line
Thorax p.a.
Thorax p.a.
−
+
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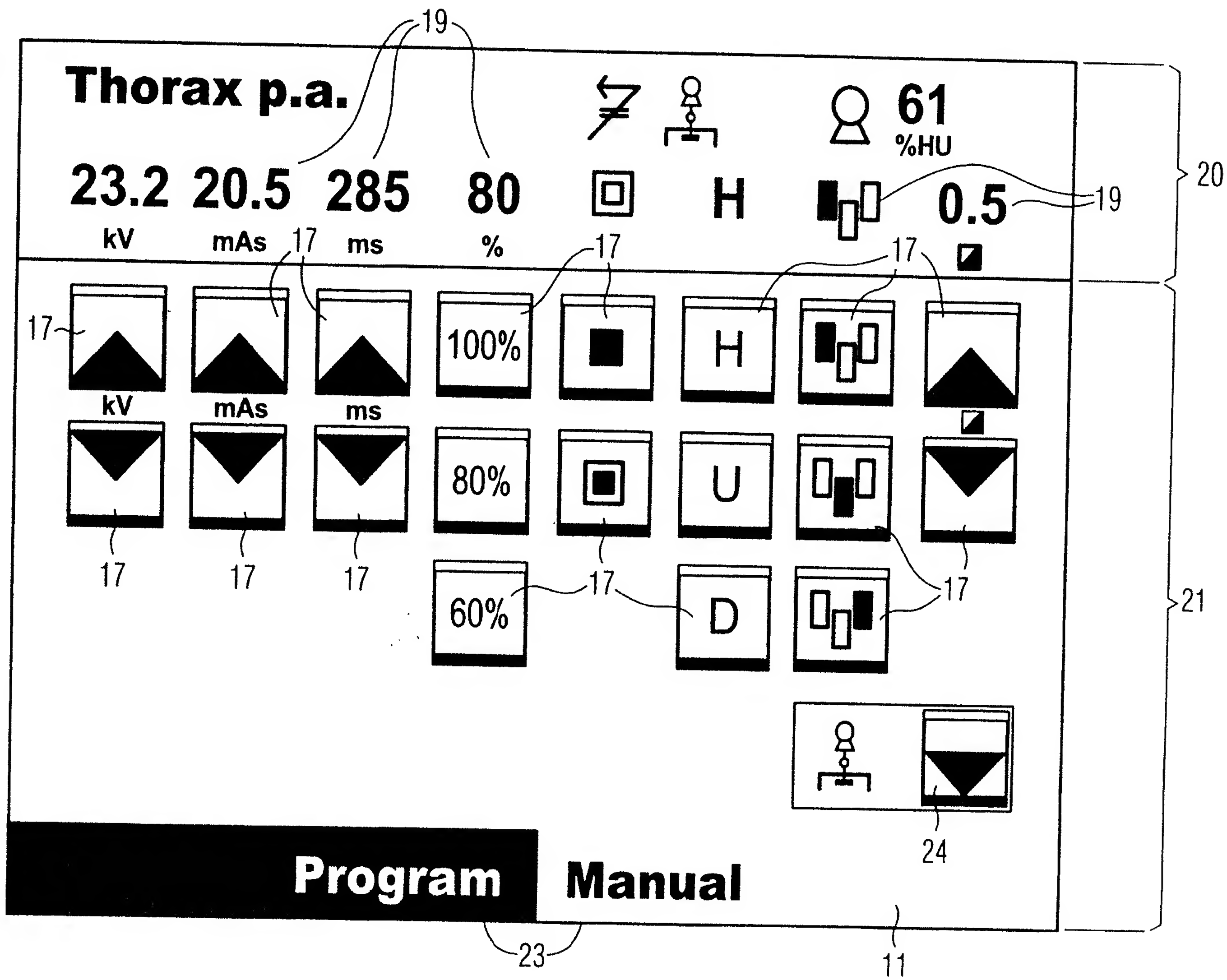
Manual
11
14
15
16
19
20
21
23
24

FIG 3



Thorax p.a.
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kV
20.5
mAs
285
ms
80
%
H
61
%HU
0.5
100%
H
kV
mAs
ms
80%
U
60%
D
Program
Manual
19
17
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21
23
24
11

US006795528B2

(12) **United States Patent**
Nokita

(10) **Patent No.: US 6,795,528 B2**
(45) **Date of Patent: Sep. 21, 2004**

(54) **RADIOGRAPHIC APPARATUS, RADIOGRAPHIC METHOD, AND COMPUTER-READABLE STORAGE MEDIUM**

(75) Inventor: **Makoto Nokita**, Tochigi (JP)

(73) Assignee: **Canon Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/035,154**

(22) Filed: **Jan. 4, 2002**

(65) **Prior Publication Data**

US 2002/0101960 A1 Aug. 1, 2002

(30) **Foreign Application Priority Data**

Jan. 12, 2001 (JP) 2001-005563

(51) **Int. Cl.**[7] **G21K 1/00**
(52) **U.S. Cl.** **378/155**
(58) **Field of Search** 378/95, 96, 98.7, 378/108, 154, 155

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* cited by examiner

Primary Examiner—David V. Bruce
Assistant Examiner—Allen C. Ho
(74) *Attorney, Agent, or Firm*—Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

A radiographic apparatus is disclosed which controls a movement of a reciprocatingly moving grid so that the grid is not or less likely returned in the middle of exposure of an object to X rays. The probability that the object is still exposed to the X rays when the grid is moved in the vicinity of a turning point is thus substantially lowered. Therefore the probability that a resulting radiograph has no or less moire pattern due to the grid is substantially heightened.

5 Claims, 9 Drawing Sheets

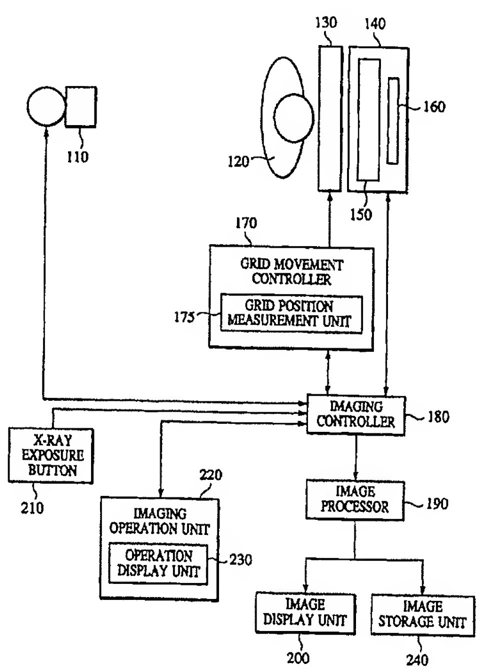


FIG. 1

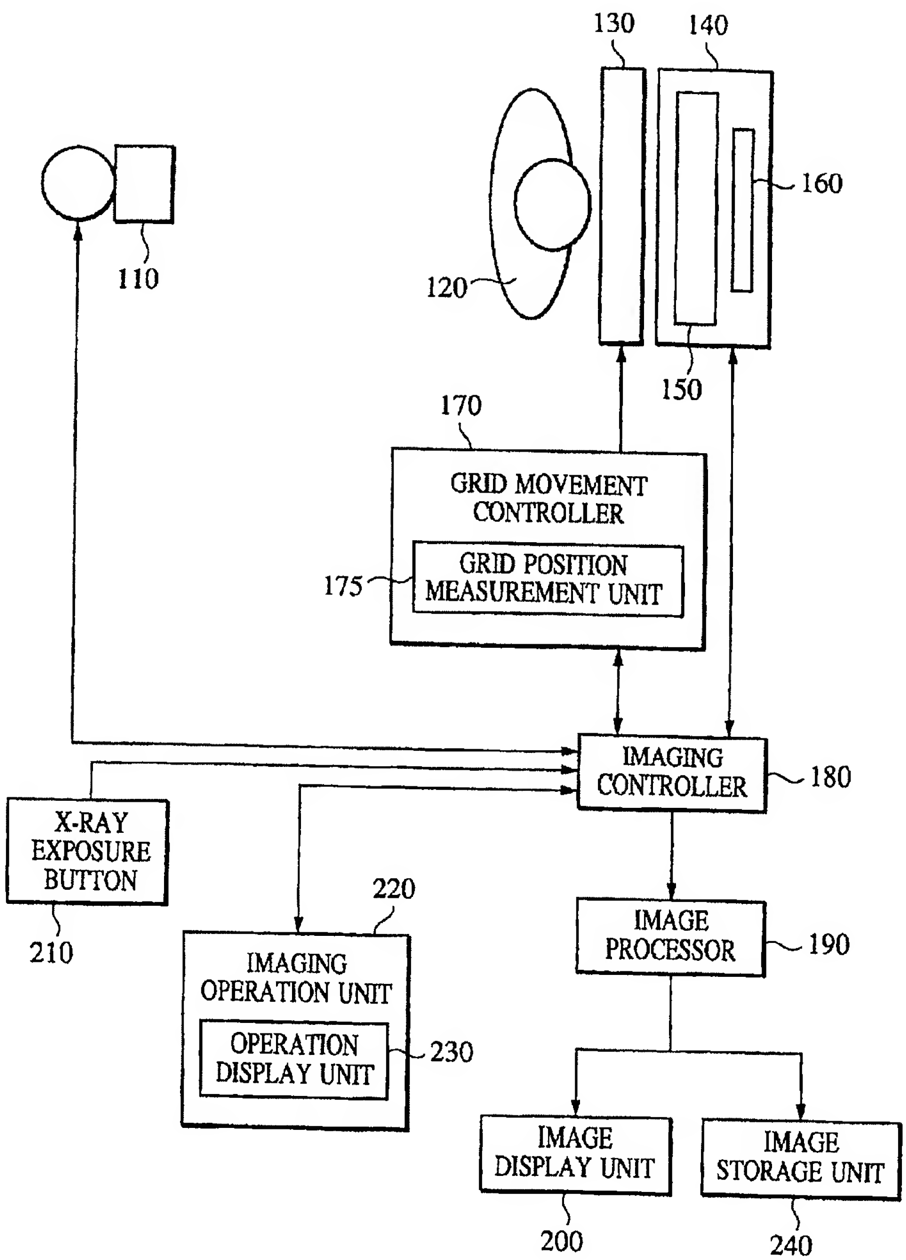

130
140
160
110
120
150
170
GRID MOVEMENT CONTROLLER
GRID POSITION MEASUREMENT UNIT
175
IMAGING CONTROLLER
180
X-RAY EXPOSURE BUTTON
210
220
IMAGING OPERATION UNIT
OPERATION DISPLAY UNIT
230
IMAGE PROCESSOR
190
IMAGE DISPLAY UNIT
200
IMAGE STORAGE UNIT
240

FIG. 2

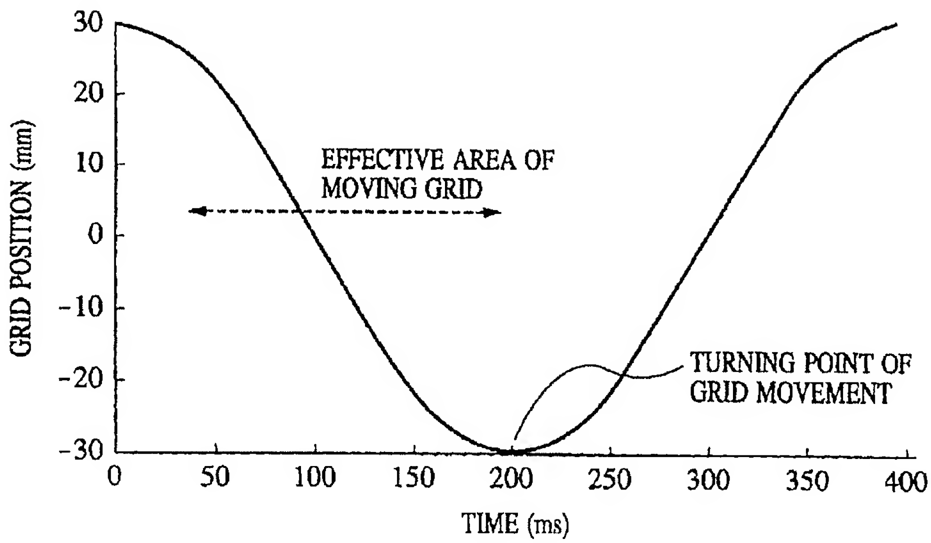

30
20
10
0
-10
-20
-30
GRID POSITION (mm)
0
50
100
150
200
250
300
350
400
TIME (ms)
EFFECTIVE AREA OF MOVING GRID
TURNING POINT OF GRID MOVEMENT

FIG. 3

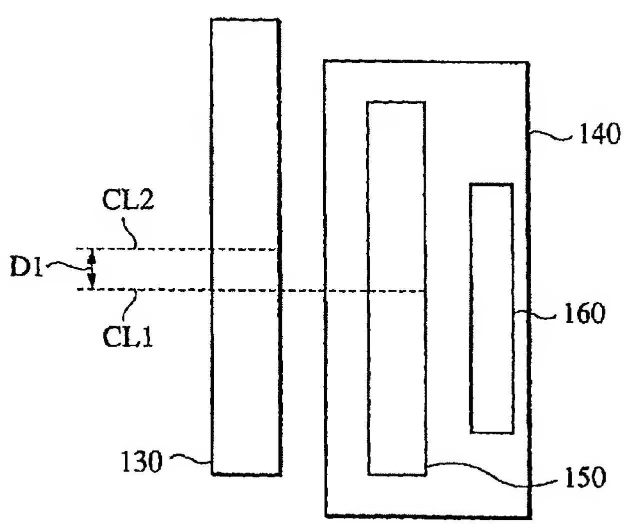

140
CL2
D1
CL1
160
130
150

FIG. 4

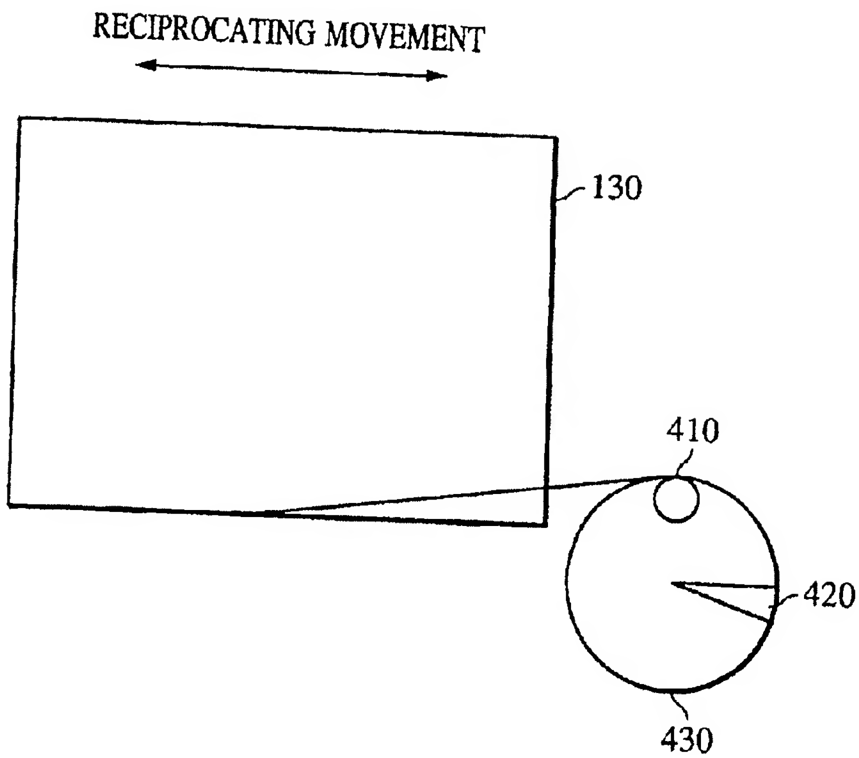


FIG. 5

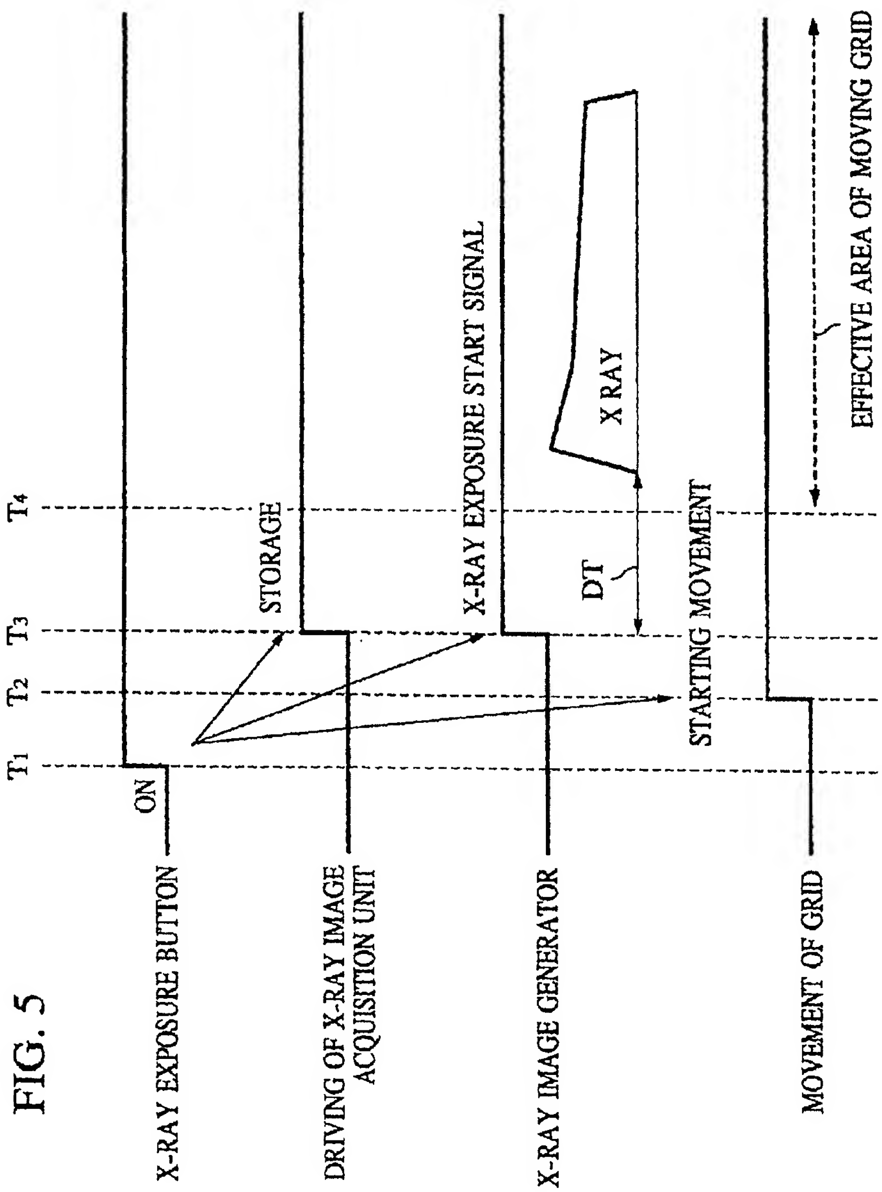
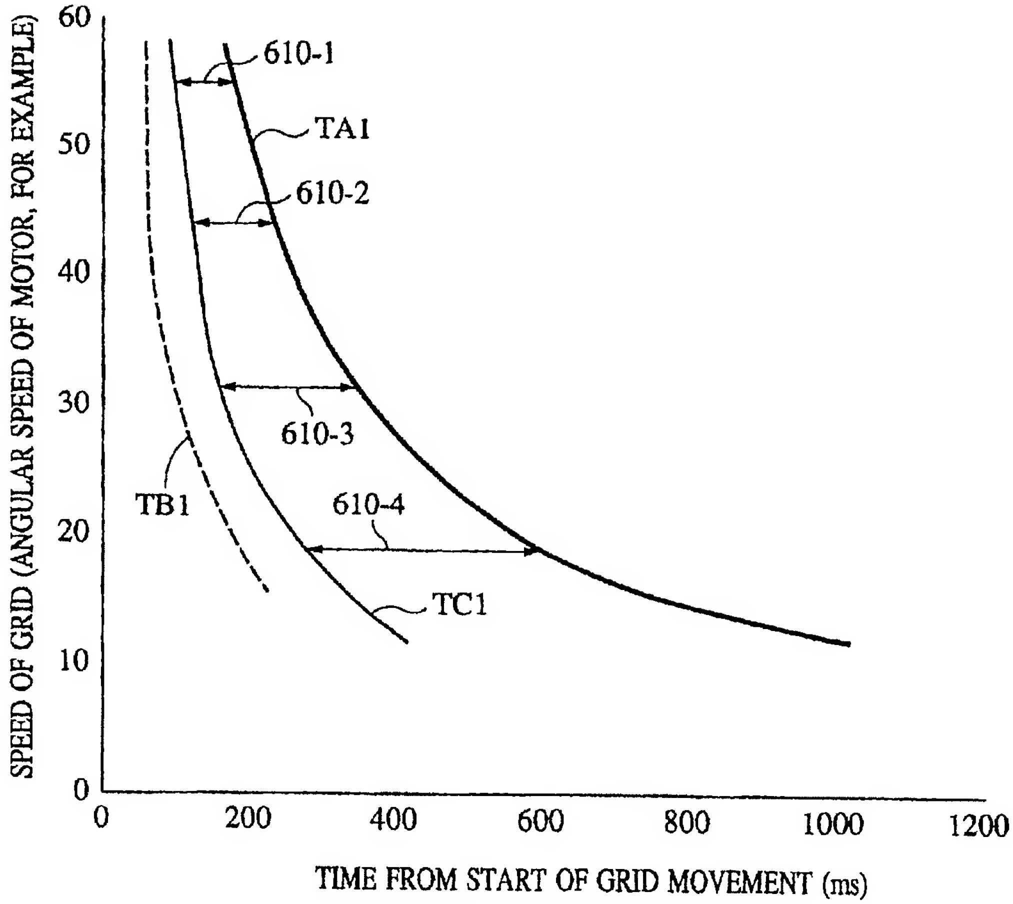

X-RAY EXPOSURE BUTTON
ON
DRIVING OF X-RAY IMAGE ACQUISITION UNIT
STORAGE
X-RAY IMAGE GENERATOR
X-RAY EXPOSURE START SIGNAL
X RAY
DT
STARTING MOVEMENT
MOVEMENT OF GRID
EFFECTIVE AREA OF MOVING GRID
T1
T2
T3
T4

FIG. 6



SPEED OF GRID (ANGULAR SPEED OF MOTOR, FOR EXAMPLE)
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
TIME FROM START OF GRID MOVEMENT (ms)
610-1
TA1
610-2
610-3
610-4
TB1
TC1

FIG. 7

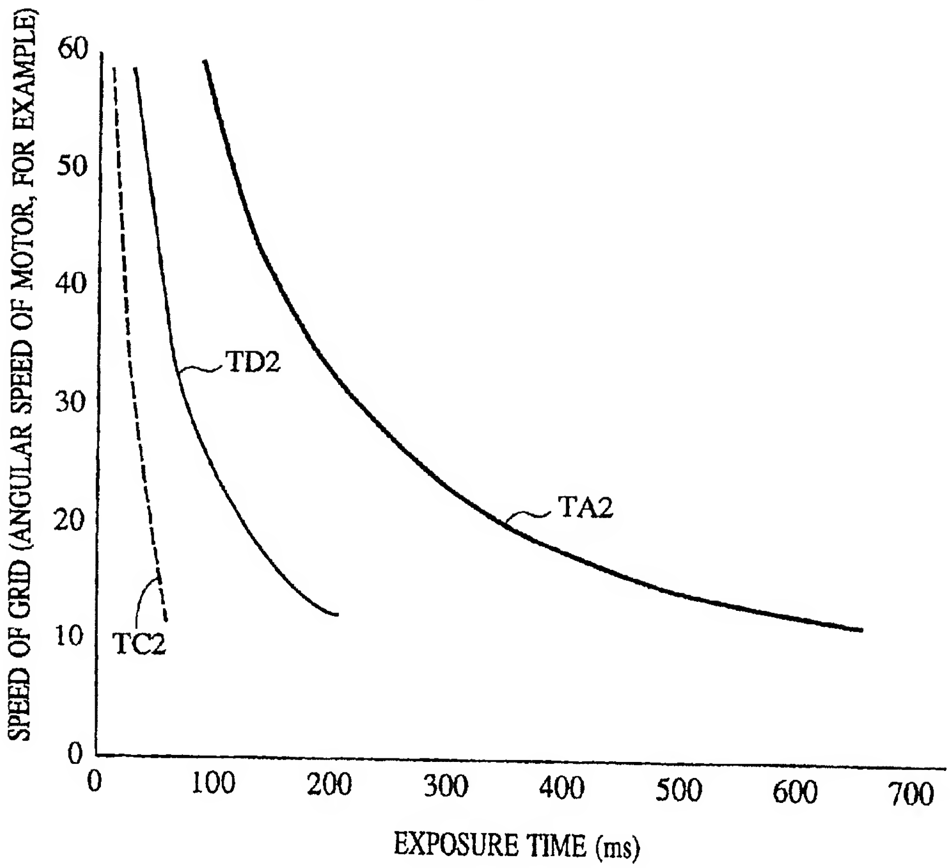

SPEED OF GRID (ANGULAR SPEED OF MOTOR, FOR EXAMPLE)
60
50
40
30
20
10
0
TD2
TA2
TC2
0
100
200
300
400
500
600
700
EXPOSURE TIME (ms)

FIG. 8A

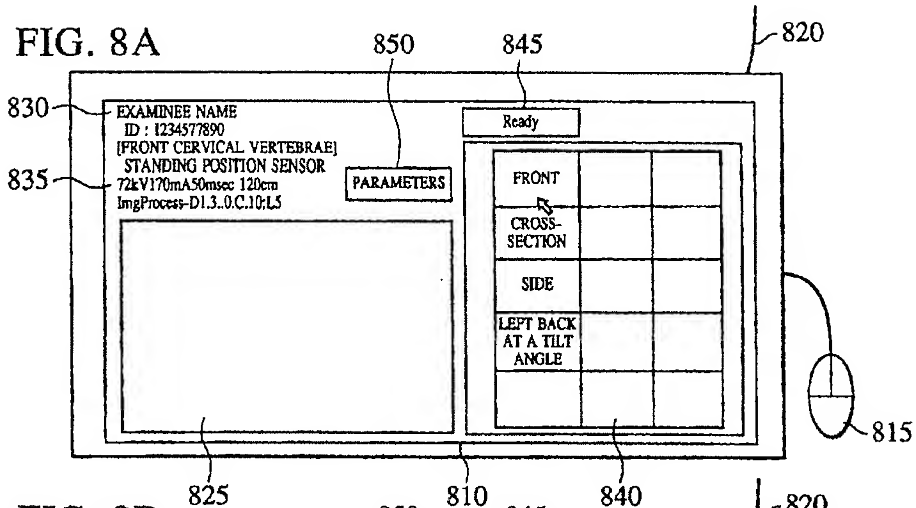


FIG. 8B

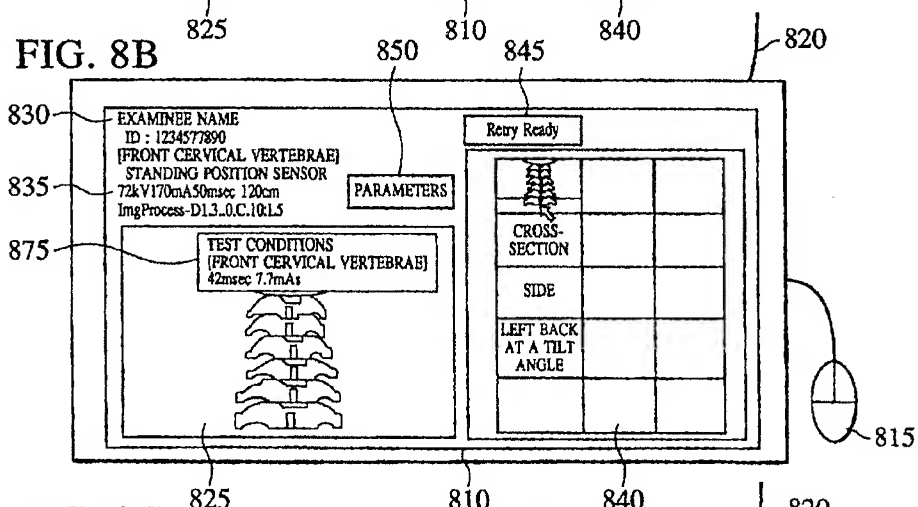


FIG. 8C

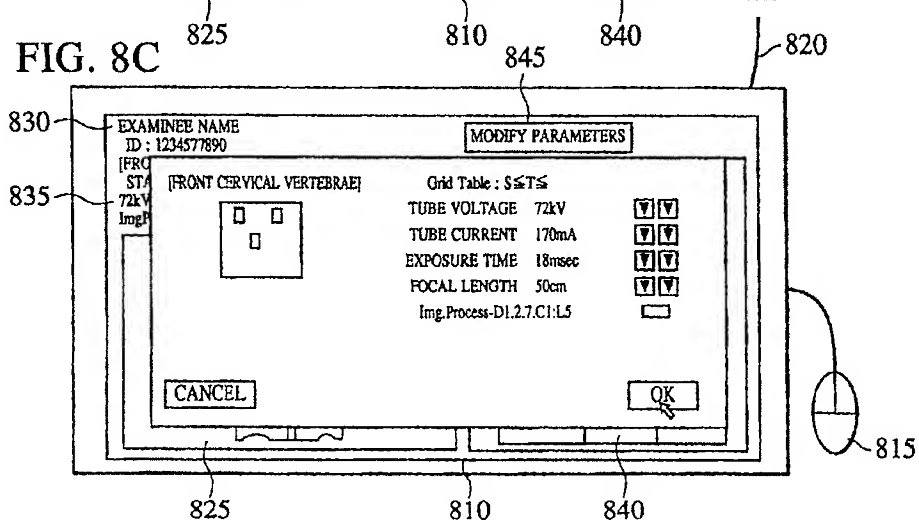


FIG. 9

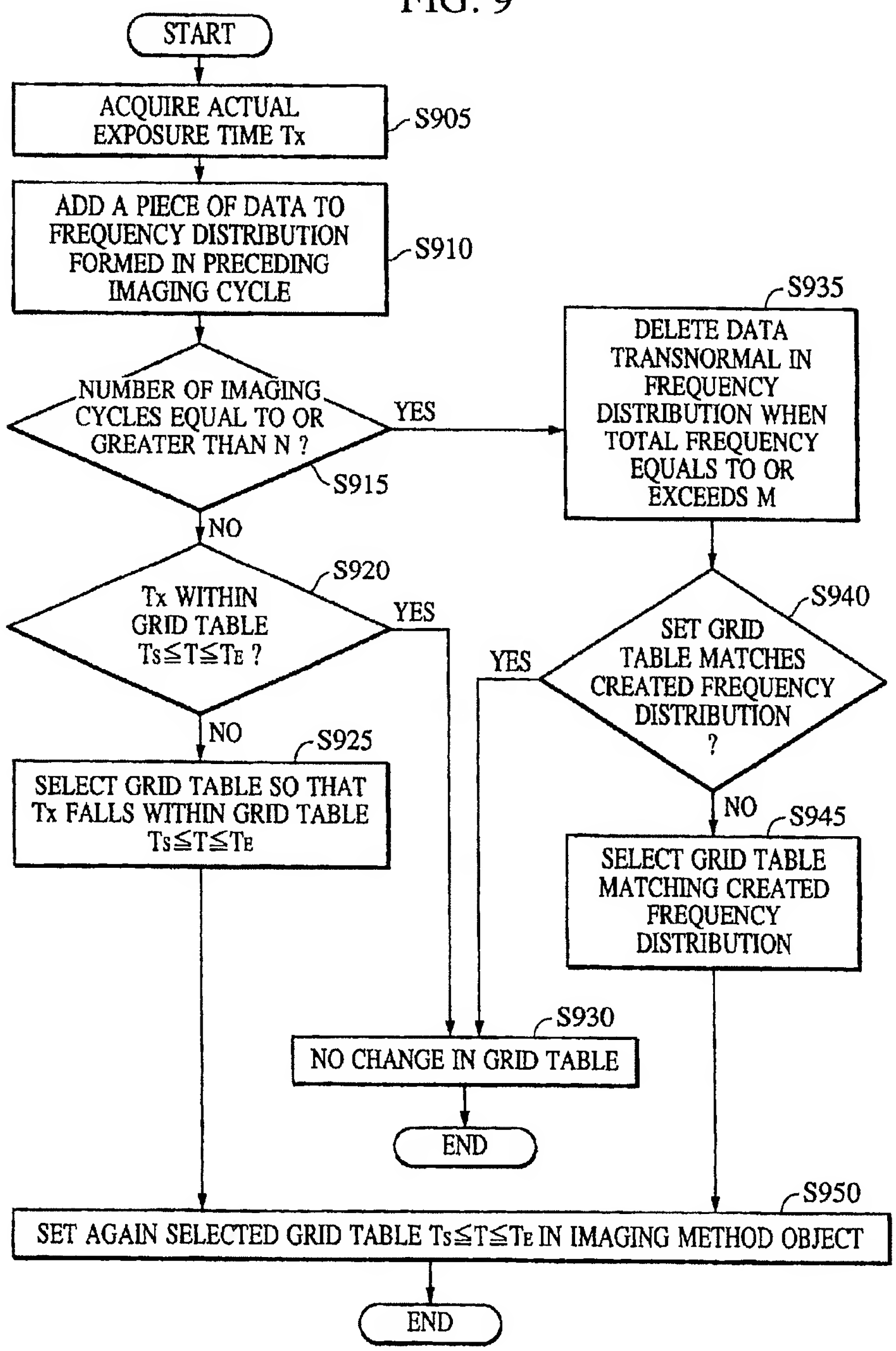
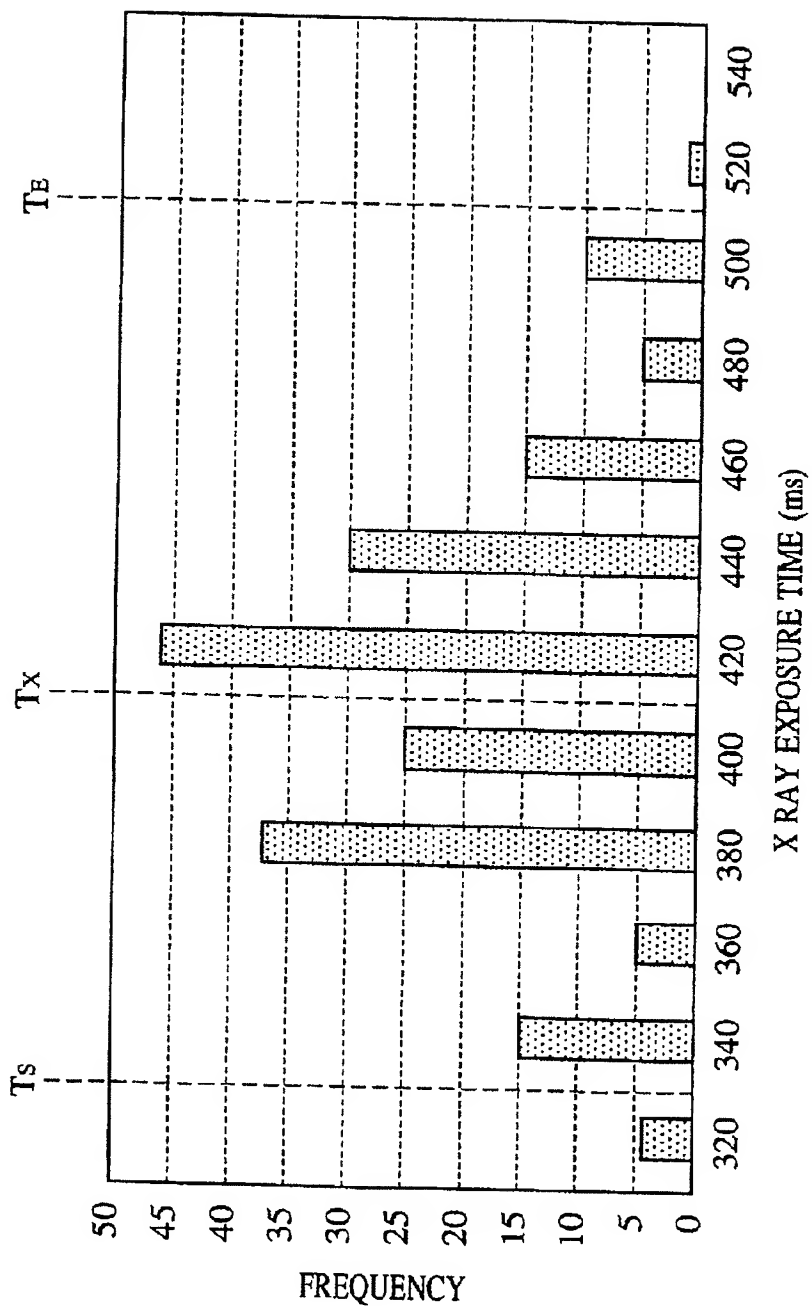

START
ACQUIRE ACTUAL EXPOSURE TIME Tx
S905
ADD A PIECE OF DATA TO FREQUENCY DISTRIBUTION FORMED IN PRECEDING IMAGING CYCLE
S910
NUMBER OF IMAGING CYCLES EQUAL TO OR GREATER THAN N ?
S915
YES
NO
DELETE DATA TRANSNORMAL IN FREQUENCY DISTRIBUTION WHEN TOTAL FREQUENCY EQUALS TO OR EXCEEDS M
S935
Tx WITHIN GRID TABLE Ts≦T≦Te ?
S920
YES
NO
SET GRID TABLE MATCHES CREATED FREQUENCY DISTRIBUTION ?
S940
YES
NO
SELECT GRID TABLE SO THAT Tx FALLS WITHIN GRID TABLE Ts≦T≦Te
S925
SELECT GRID TABLE MATCHING CREATED FREQUENCY DISTRIBUTION
S945
NO CHANGE IN GRID TABLE
S930
END
SET AGAIN SELECTED GRID TABLE Ts≦T≦Te IN IMAGING METHOD OBJECT
S950
END

FIG. 10



T_S
T_X
T_E
FREQUENCY
50
45
40
35
30
25
20
15
10
5
0
320
340
360
380
400
420
440
460
480
500
520
540
X RAY EXPOSURE TIME (ms)

RADIOGRAPHIC APPARATUS, RADIOGRAPHIC METHOD, AND COMPUTER-READABLE STORAGE MEDIUM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a radiographic apparatus, a radiographic method, and a computer-readable recording medium, which can use a scattered radiation removal grid for removing radiation scattered by and within an object when the object is radiographed.

2. Description of the Related Art

Radiographing such as X-ray imaging has been used in diagnosis in medical practice, and examination and test of industrial products, for example. In X-ray imaging, an object is exposed to X rays, and X rays transmitted through the object are used to photosensitize a film or a screen. An X-ray image is thus obtained. The X rays transmitted through the object contain X rays linearly transmitted through the object and X rays that have been scattered within the object and then transmitted therethrough (hereinafter referred to as "scattered X rays"). In X ray imaging, the scattered X rays degrade the contrast of an X ray image, thereby substantially affecting the quality of the X-ray image.

A scattered X ray removal grid (hereinafter simply referred to as a "grid") is arranged parallel to the plane of imaging to efficiently remove the scattered X rays thereby improving the contrast of the X-ray image. The grid is formed of lead foils that are arranged so as to focus toward a focal point of an X-ray source, or lead foils that are arranged perpendicular to the imaging plane. The grid facilitates the transmission of X rays that have entered after being linearly transmitted through the object from the focal point of the X-ray source while blocking the X rays that are incident at a slant angle after being scattered within the object.

In the conventional X-ray imaging using a film/screen system with the grid, the frequency of stripe-like lead foils of grid (i.e., the reciprocal number of the pitch of the lead foils, also referred to as a "grid frequency" or a "grid density") is typically set higher than a frequency component of an ordinary X-ray image (on the assumption that no grid is employed) so that a striped pattern, occurring due to the grid in the X-ray image, is inconspicuous. By moving the grid in parallel to the imaging plane, the contrast of the striped pattern occurring due to the grid is reduced to make the striped pattern less visible or invisible in the X-ray image.

Digital radiographic apparatuses have been used. The digital radiographic apparatus obtains X-ray image data by converting the X rays transmitted through the object into visible light rays proportional to the intensity of the X rays through a fluorescent material (scintillator), converting the visible light rays into electrical signals through a photoelectric conversion element comprising a plurality of pixels, and (analog-to-digital) converting the electrical signals by an AD converter. Digital radiographic apparatuses of a sort begin to be used which obtain X-ray image data by sensing the distribution of electric charges proportional to the intensity of X rays that result from directly absorbing (through photoelectric conversion) X rays transmitted through an object, converting the charges into electrical signals, and (analog-to-digital) converting the electrical signals through an AD converter.

The above-mentioned digital radiographic apparatuses present an X-ray absorption ratio higher than that of the conventional film/screen system, and is free from a mottle structure that degrades granularity of an image in the conventional film/screen system. An X-ray image obtained from the above-mentioned digital radiographic apparatus is a digital image. Therefore the X-ray image is not necessarily output with a predetermined tone scale characteristics the same as that used in a film/screen system. Observing an X-ray image on a monitor, a user may freely change the tone scale characteristics. The user is also free to perform image processing such as frequency analysis, frequency enhancement or suppression processing or the like on the resulting X-ray image, thereby improving image quality.

The digital radiographic apparatus using the above-mentioned scattered X ray removal grid suffers from a moire pattern (a striped pattern, here) which does not exist in the X-ray image in the conventional film/screen system. The moire pattern is generated on the basis of a difference between the pixel pitch of a sensor for sensing the X ray as an electrical signal and the pitch of the lead foils forming the grid (the reciprocal number of the grid density). Let Ny represent the Nyquist frequency of the sensor and Gy represent the grid frequency (the grid density), and the frequency of the moire pattern is expressed as 2 Ny−Gy.

For example, when the Nyquist frequency Ny is 2.5 lp/mm (the pixel pitch of the sensor is 200 μm) and the grid frequency Gy is 4.0 lp/mm (40 lines/cm), the frequency of the moire pattern is 1.0 lp/mm. Since this frequency component is the one appearing in the typical X-ray images, the moire pattern is distinctly visible, thereby substantially degrading the quality of the resulting X-ray images. Here, lp/mm stands for line pairs per mm. The resolving power of the radiographic apparatus is sometimes measured using a chart having lead lines. The resolving power is defined by referring to how many pairs of the presence and absence of the lead line are recognized per unit length.

With the advance of technology, the digital radiographic apparatus provides an X-ray absorption ratio and resolving power higher than those of the conventional film/screen radiographic apparatus using the film/screen system. Viewing the screen of a monitor, the user is free to change the tone scale of the X-ray image. Therefore the component of the moire pattern having some contrast, as opposed in the conventional X-ray imaging, becomes a problem. Accordingly, a movement method of the grid different from that in the conventional film/screen system and a radiographing method accounting for the movement method are needed to make the moire pattern removed or inconspicuous.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a radiographic apparatus, a radiographic method, and a computer-readable storage medium for acquiring a radiograph, wherein the probability that a moire pattern is not generated or, is inconspicuous in the radiograph is heightened.

In one aspect of the present invention, a radiographic apparatus for obtaining a radiograph of an object includes a grid movement controller for controlling a movement of a grid which can move reciprocatingly, an input unit for inputting a method parameter relating to a radiographic method, and an imaging controller for setting a movement parameter relating to the movement of the grid to be used by said grid movement controller based on the method parameter input by the input circuit.

In another aspect of the present invention, a radiographic method for obtaining a radiograph of an object, includes the steps of controlling a movement of a grid which can move reciprocatingly, inputting a method parameter relating to a radiographic method, and setting a movement parameter relating to the movement of the grid to be used in said grid movement controlling step based on the method parameter input in said inputting step.

Further objects, features, and advantages of the present invention will be apparent from the following description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an X-ray digital radiographic apparatus in accordance with one embodiment of the present invention.

FIG. 2 is a graph plotting the interrelationship between an elapsed time from the beginning of movement of a grid and a position of the grid.

FIG. 3 illustrates the interrelationship between the grid and a sensor.

FIG. 4 illustrates the construction of a grid position measurement unit.

FIG. 5 is a timing diagram illustrating timings of the movement of the grid, operation of the sensor, and irradiating X rays.

FIG. 6 is a graph for determining an exposure time of the X rays.

FIG. 7 is a graph plotting the interrelationship of standard X-ray exposure time, minimum X-ray exposure time, and maximum X-ray exposure time.

FIGS. 8A–8C illustrate operation screens of an operation display unit.

FIG. 9 is a flow diagram illustrating an operation in which a grid table is automatically adjusted when a set grid table fails to match an actual exposure time.

FIG. 10 plots an example of a frequency distribution.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the present invention is now discussed, referring to the drawings.

FIG. 1 is a block diagram showing a digital radiographic apparatus in accordance with one embodiment of the present invention.

Referring to FIG. 1, an X-ray emitter 110, i.e., an X-ray source, emits and directs X rays to an object 120 during X-ray imaging. A grid 130 removes scattered X rays that have been generated within the object 120 which scatters X-ray emitted from the X-ray emitter 110.

A sensor 140 senses the X rays transmitted through the object 120 to obtain an X-ray image (a radiograph) of the object 120, and includes an X-ray image acquisition unit 150 and an X-ray timing acquisition unit 160. The X-ray image acquisition unit 150 detects the X rays transmitted through the object 120, converts the X rays into an electrical signal in accordance with the intensity of the X rays, and further converts the electrical signal from analog to digital to obtain an X-ray image. The X-ray timing acquisition unit 160 detects the X rays emitted from the X-ray emitter 110 and transmitted through the object 120 on a time division basis.

A grid movement controller 170 includes a grid position measurement unit 175. In response to the results of a

measurement by the grid position measurement unit 175 and a command from an imaging controller 180, the grid movement controller 170 controls the movement of the grid 130 while assuring alignment with the timing of the X-ray imaging. The grid position measurement unit 175 under the control of the grid movement controller 170 measures the position of the grid 130.

The imaging controller 180 controls X-ray imaging by commanding that the grid 130 should be moved and by driving the sensor 140. An image processor 190 processes an X-ray image acquired by the X-ray image acquisition unit 150 so that a user may easily recognize the image. An image display unit 200 displays the X-ray image processed by the image processor 190. An image storage unit 240 stores the X-ray image processed by the image processor 190.

Pressing an X-ray exposure button 210 starts the X-ray imaging. An imaging operation unit 220, including an operation display unit 230, receives various parameters which the user inputs to control the X-ray imaging. The operation display unit 230 with the display or the touch screen thereof displays imaging operation items input via the imaging operation unit 220.

When the user presses the X-ray exposure button 210, the above-described digital radiographic apparatus directs the X rays to the object 120 from the X-ray emitter 110 in response to a command of the imaging controller 180. The X rays, emitted from the X-ray emitter 110 and transmitted through the object 120, enter the sensor 140 through the moving grid 130.

The X rays incident on the sensor 140 are detected by the X-ray image acquisition unit 150 in the sensor 140 in the form of an electrical signal. The X-ray image acquisition unit 150 also converts the electrical signal into a digital signal. The X-ray image in the digital form is then fed to the image processor 190 through the imaging controller 180.

The image processor 190 improves image quality by subjecting the X-ray image to a predetermined image processing, thereby displaying the X-ray image on the image display unit 200 or storing the X-ray image in the image storage unit 240 or both.

During X-ray imaging, the imaging controller 180 controls the grid movement controller 170 and the sensor 140 on the basis of the timing at which the X-ray emitter 110 expose the object 120 to the X rays. In this way, the timing of the irradiation of the X rays from the X-ray emitter 110 matches the timing of the movement of the grid 130 and the driving of the sensor 140.

Discussed in greater detail below is the timing of the imaging controller 180 for controlling the driving of the grid movement controller 170 and the sensor 140, and the grid movement controller 170 for controlling the movement of the grid 130.

The grid movement controller 170 for controlling the movement of the grid 130 is discussed below.

Referring to FIG. 4, the grid movement controller 170 moves the grid 130 using a link mechanism that converts a rotary motion of a pulse motor (shown in FIG. 4) into a linearly reciprocating motion (shown in FIG. 2).

FIG. 2 is a graph plotting the interrelationship between an elapsed time from the beginning of movement of the grid 130 and the position of the grid 130 relative to the sensor 140. The abscissa represents the elapsed time from the beginning of the movement, while the ordinate represents the position of the grid 130 relative to the sensor 140.

FIG. 3 illustrates the position of the grid 130 of FIG. 2 with respect to the sensor 140, viewed from above the grid

130 and the sensor 140. Referring to FIG. 3, blocks identical to those described with reference to FIG. 1 are designated with the same reference numerals, and the discussion thereof is omitted.

Referring to FIG. 3, CL1 designates the center line of the X-ray image acquisition unit 150 in the sensor 140, and CL2 designates the center line of the grid 130. D1 is the distance between the center line CL1 and the center line CL2. The position of the grid 130 with respect to the sensor 140 is regarded as having a positive value when the center line CL2 of the grid 130 is located to the right of the center line CL1 of the X-ray image acquisition unit 150 (i.e., with the center line CL2 below the center line CL1 in FIG. 3) if the X-ray image acquisition unit 150 is viewed from the unshown X-ray emitter 110. The position of the grid 130 with respect to the sensor 140 is regarded as having a negative value when the center line CL2 of the grid 130 is located to the left of the center line CL1 of the X-ray image acquisition unit 150 (i.e., with the center line CL2 above the center line CL1 in FIG. 3). The position of the grid 130 with respective to the sensor 140 shown in FIG. 3 has a negative value (of −30 mm).

In the interrelationship between the elapsed time from the beginning of the movement of the grid 130 and the position of the grid 130 with respect to the sensor 140 as shown in FIG. 2, the grid 130 starts moving from a point 30 mm right of the center of the sensor 140 (i.e., at +30 mm) at the start of movement, namely, at time zero (at the beginning of rotation of a pulse motor when the pulse motor is used to drive the grid 130). The grid 130 moves to a position of a value that is determined by equation of 30 cos (ωt) (ω is an angular speed of the pulse motor), and reaches to a point 30 mm left of the center line CL1 of the sensor 140 (i.e., at −30 mm) at time 200 ms. The grid 130 returns toward the center line CL1 of the sensor 140 from the point 30 mm left thereof, and then reaches to the point 30 mm right of the center line CL1 of the sensor 140 (namely, at the start point) at time 400 ms.

The grid 130 moves reciprocatingly in front of the sensor 140 as shown in FIG. 2. In this case, the grid 130 momentarily stops and resumes a turn movement at the end of the reciprocating movement (for example, at the point 30 mm left of the center line CL1 of the sensor 140 (i.e., at −30 mm)).

When the grid 130 turns in this way, the grid 130 momentarily stops moving. In case that the X rays irradiating the object 120 and transmitted through the object 120 enter the sensor 140 when the grid 130 momentarily comes to a halt, a striped pattern attributable to the grid 130 distinctly appears in the resulting X-ray image. In other words, the moire pattern due to the grid 130 becomes pronounced in the resulting X-ray image obtained by the X-ray image acquisition unit 150.

To make the striped pattern attributable to the grid 130 less visible in the resulting X-ray image, the grid 130 needs to be controlled such that exposure of the object 120 to the X rays ends before the grid 130 reaches a turning point thereof.

The position of the grid 130 with respect to the sensor 140 at the start of the X-ray exposure will now be discussed.

Now the object 120 is irradiated with X-ray with the grid 130 passing the zero point as shown in FIG. 2 (for a predetermined duration of time with the grid 130 being in the vicinity of the zero point) when the grid 130 moves fast. The intensity distribution of the X rays obtained by the X-ray image acquisition unit 150 is less subject to the cutoff effect of the grid 130. Since the movement speed of the grid 130 is the fastest in the vicinity of the zero point along the path of the grid 130, contrast of the striped pattern due to the grid 130 is minimized in the resulting X-ray image.

Exposure of the object 120 to the X rays now starts with the grid 130 moving slowly in the vicinity of the start point of the movement (at 30 mm) as shown in FIG. 2. In this case, the object 120 can be irradiated with X rays for a relatively long time from the start of the movement of the grid 130 to the turning point thereof.

The grid movement controller 170 includes the grid position measurement unit 175 to measure the position of the grid 130 in the movement thereof as discussed above.

FIG. 4 shows an example of the grid position measurement unit 175. Referring to FIG. 4, there are shown the grid 130, and a link mechanism 410 which converts the rotary motion of the pulse motor into a reciprocating movement of the grid 130. A notch 420 is formed in a rotary disk 430.

The rotary disk 430 having the notch 420 is attached to the rotary shaft of the pulse motor for driving the grid 130. An initial position of the pulse motor is determined by detecting light, emitted by an unshown LED (Light Emitting Diode), through the notch 420 using a photosensor such as a photodiode. When the grid 130 starts moving, the grid position measurement unit 175 counts the number of pulses that are fed to drive the pulse motor, thereby determining the angle of rotation of the pulse motor, and thereby determining the position of the grid 130.

The grid position measurement unit 175 shown in FIG. 4 is an exemplary construction. The grid position measurement unit 175 is not limited to the exemplary construction shown in FIG. 4. Alternatively, the position of the grid 130 itself may be measured, and the results of measurement may be fed to the grid movement controller 170.

There occurs a delay time from the pressing of the X-ray exposure button 210 to the actual exposure of the object 120 to X rays from the X-ray emitter 110 (an X-ray generator, for example). To match the movement of the grid 130 and the driving of the sensor 140 with the irradiation of X rays from the X-ray emitter 110 in timing, a delay time needs to be measured beforehand from the pressing of the X-ray exposure button 210 (more precisely, from the supply of an X-ray exposure start signal to the X-ray emitter 110) to the actual irradiation of X rays from the X-ray emitter 110.

The X-ray timing acquisition unit 160 in the sensor 140 is used to measure the delay time. The X-ray timing acquisition unit 160 has the function of chronologically or successively measuring the intensity of X rays emitted from the X-ray emitter 110 subsequent to the pressing of the X-ray exposure button 210.

Referring to FIG. 5, the timings of the movement of the grid 130, the driving of the sensor 140, and the irradiation of X rays from the X-ray emitter 110 are discussed in greater detail below.

FIG. 5 is a timing diagram showing the timings of the movement of the grid 130, the driving of the sensor 140, and the irradiation of X rays.

Referring to FIG. 5, the X-ray exposure button 210 is pressed to begin X-ray exposure at time T_1. The grid movement controller 170 controls the grid 130 at time T_2 after a predetermined time elapsed from time T_1 to move the grid 130. The predetermined time is determined so that the effective duration of time of the moving grid (corresponding to an effective area) shown in FIG. 2 and FIG. 4 includes a duration of time (assumed exposure time) during which the X rays are irradiated from the X-ray emitter 110.

At time T_3, the X-ray image acquisition unit **150** starts an accumulation operation for accumulating the X ray signal transmitted through the object **120**. The accumulation operation lasts until the intensity of the X rays acquired by the X-ray timing acquisition unit **160** becomes zero. At time T_3, the X-ray exposure start signal is fed to the X-ray emitter **110**, and the X-ray emitter **110** begins generating X rays. The X-ray emitter **110** has a delay time DT, characteristic of the X-ray generator, from the supply of the X-ray exposure start signal to the actual irradiation of X rays. The delay time DT is measured (beforehand) using the X-ray timing acquisition unit **160**, and then the start time of the accumulation operation by the X-ray image acquisition unit **150** is determined (i.e., the start time of the accumulation operation is delayed by a predetermined time from the supply time of the X-ray exposure start signal with the delay time DT accounted for).

The X-ray timing acquisition unit **160** measures the delay time DT. If the X-ray image acquisition unit **150** has the function of successively measuring the intensity of X rays, the X-ray image acquisition unit **150** may measure the delay time without using the X-ray timing acquisition unit **160**. Alternatively, the X-ray timing acquisition unit **160** may be arranged in the X-ray emitter **110** rather than in the sensor **140**.

FIG. **6** is a graph for determining the X-ray exposure time duration in case that the grid **130** reciprocatingly moves in front of the sensor **140**. The abscissa represents the elapsed time from the beginning of the movement of the grid **130**, while the ordinate represents the angular speed of the pulse motor corresponding to the movement speed of the grid **130**.

As shown, TA1 represents the time from when the grid **130** starts moving until when the grid **130** reaches the turning point. Specifically, TA1 indicates a reference intended to stop the exposure of the object **120** to the X rays before the turning point of the grid to reduce the contrast of the striped pattern due to the grid in the resulting X-ray image acquired by the X-ray image acquisition unit **150**.

TB1 represents the time from when the grid **130** starts moving until when the X-ray emitter **110** starts directing X rays to the object **120**, i.e., the time from when the grid **130** starts moving until the grid **130** reaches a position where the start of the irradiation of X rays is appropriate. TC1 represents the time from when the grid **130** starts moving until the moire pattern due to the grid is reduced to predetermined degree subsequent to the start of the irradiation of X rays. Specifically, the duration of time from TB1 to TC1 is the time needed for the required number of lead foil lines takes to pass by a single pixel of the X-ray image acquisition unit **150** from the beginning of the irradiation of X rays to reduce the moire pattern due to the grid to predetermined degree.

The number of passing lead foil lines of the grid **130** is obtained by dividing the product of the movement speed of the grid and the irradiation time of the X rays (i.e., the time integral of the grid movement speed, namely, the distance of travel of the grid) by the pitch of the lead foil of the grid **130**. When the movement speed of the grid **130** and the pitch of the lead foils of the grid **130** are determined, a required X-ray exposure time to reduce the moire pattern to predetermined degree is calculated from the required number of passing lead foil lines of the grid **130**. The X-ray image acquisition unit **150** thus acquires the X-ray image free from the moire pattern by causing the X-ray emitter **110** to start the exposure of the object **120** to the X rays from TB1, and to end the exposure of the object **120** to the X rays for somewhere between any of durations **610-1, 610-2, 610-3,** and **610-4** (i.e., between TC1 and TA1) as shown in FIG. **6**.

By selecting (appropriate exposure time) appropriate one of the durations of time corresponding to the movement speed of the grid **130** (i.e., the angular speed of the pulse motor), a grid table is formed and stored in the imaging controller **180**. The grid table is displayed on the operation display unit **230** on the imaging operation unit **220** so that an operator (a user) of the digital radiographic apparatus may utilize the grid table.

Specifically, the grid table is formed and displayed in the form of $T_S \leqq T \leqq T_E$ in accordance with the movement speed of the grid **130** (or the angular speed of the step motor), wherein T_S represents a minimum X-ray exposure time and T_E represents a maximum X-ray exposure time. The minimum X-ray exposure time T_S is determined by subtracting the value of TB1 from the value of TC1 for each movement speed of the grid **130**. The maximum X-ray exposure time T_E is determined by subtracting the value of TB1 from the value of TA1 for each movement speed of the grid **130**.

As described above, the digital radiographic apparatus tends to suffer from a degradation in the image quality of the X-ray image attributable to the moire pattern caused by the grid. Therefore, in X-ray imaging, the movement of the grid **130** needs to be precisely controlled. A time interval of the grid table $T_S \leqq T \leqq T_E$ is shorter than that permitted in the conventional film/screen system. A plurality of grid tables is thus prepared to permit a wide range of choice in the grid tables during X-ray imaging.

For example, when the chest of a human body is X-ray imaged, the X-ray exposure time is set to be as short as 10 ms so that a heart and the peripheral portion thereof are not blurred in the X ray image regardless of the heart beat. However, there are times when the X-ray exposure time becomes as long as one second because the transmittance of the X rays through the abdomen and the like of the human is typically low. To radiograph the human body, the digital radiographic apparatus must work with the exposure time ranging from several ms to several hundred ms or several seconds. Thus, a plurality of grid tables (for example, four or more grid tables) are required.

However, the use of multiple grid tables provided is accompanied by an inconvenience. The operator of the digital radiographic apparatus has difficulty in properly selecting the grid table appropriate for each X ray imaging application. In accordance with this embodiment, an imaging button corresponding to each region of the body to be imaged is arranged in the imaging operation unit **220**, and is associated with the respective grid table. When the operator presses one imaging button, the grid table corresponding thereto is automatically selected. Based on the selected grid table, the grid movement controller **170** controls the movement of the grid **130**.

In the imaging method that is set by an imaging button corresponding to each region of the body, a predetermined grid table chosen based on a standard imaging time (an X-ray exposure time) is selected.

Recently, imaging information (imaging request or ordering information) is transmitted and received through an HIS/RIS (Hospital Information System/Radiology Information System) system, and information for each region of the object (information concerning a region to be imaged) included in the imaging information is associated with a predetermined grid table. When the imaging information is received, the imaging controller **180** automatically selects a grid table matching the imaging information, and designates the movement speed of the grid **130** based on the selected grid table. The grid movement controller **170** controls the

movement of the grid **130** in accordance with the designated movement speed of the grid **130**, thereby appropriately moving the grid **130**.

When the movement speed of the grid **130** is continuously varied, the minimum X-ray exposure time T_s and the maximum X-ray exposure time T_E in the grid table formed in accordance with FIG. **6** are substantially also continuously varied. A grid table $T_S \leqq T \leqq T_E$ thus selected is more appropriate for the imaging region than one grid table which is selected from a plurality of grid tables $T_S \leqq T \leqq T_E$ that are formed in response to the discretely selected movement speeds of the grid **130**.

When the number of grid tables is increased to allow a grid table appropriate for an imaging region to be designated, a standard exposure time t is associated with the imaging region so that the operator easily selects an optimum grid table.

When the imaging button corresponding to the imaging region is pressed by the operator, or when the imaging information transmitted through the HIS/RIS system is received, the imaging controller **180** selects the standard exposure time t in response to the imaging button or the information concerning the imaging region in the imaging information, and then selects the grid table $T_S \leqq T \leqq T_E$ based on the standard exposure time t. The grid movement controller **170** thus controls the movement of the grid **130** in accordance with a grid table appropriate for the imaging region.

FIG. **7** is a graph plotting the interrelationship of the standard X-ray exposure time t, the minimum X-ray exposure time T_S, and the maximum X-ray exposure time T_E.

As shown, the abscissa represents the elapsed time (the X-ray exposure time) from when the X-ray emitter **110** has started irradiating the object **120** with the X rays, and the ordinate represents the movement speed of the grid **130**. TA2 is a curve representing the maximum X-ray exposure time T_E, namely, the value that is obtained by subtracting the value of TB1 from the value of TA1 shown in FIG. **6**. TC2 is a curve representing the minimum X-ray exposure time T_S, namely, the value that is obtained by subtracting the value TB1 from the value of TC1 shown in FIG. **6**.

Each of the curves TA2 and TC2 is plotted against the X-ray exposure time along the abscissa on a one-to-one correspondence basis. Accordingly, the minimum X-ray exposure time T_S and the maximum X-ray exposure time T_E can be a function of the standard exposure time t, and are thus respectively expressed as the minimum X-ray exposure time $T_S(t)$ and the maximum X-ray exposure time $T_E(t)$.

The standard exposure time t is set to subdivide the time interval between the minimum X-ray exposure time $T_S(t)$ and the maximum X-ray exposure time $T_E(t)$ by a ratio of m:n (m and n are natural numbers) to tolerate a deviation of an actual exposure time from the standard exposure time t depending on a difference in the thickness of the object.

For example, TD2 shown in FIG. **7** indicates the standard exposure time t that is obtained by subdividing the time interval between the minimum X-ray exposure time $T_s(t)$ and the maximum X-ray exposure time $T_E(t)$ by a ratio of 5:2.

When the operator selects the imaging region, the standard exposure time t corresponding to the imaging region is selected using the interrelationship of the standard X-ray exposure time t, the minimum X-ray exposure time T_S, and the maximum X-ray exposure time T_E shown in FIG. **7**. Also selected are the grid table $T_S \leqq T \leqq T_E$ responsive to the standard exposure time t, and the movement speed of the grid **130**. Thus, the grid movement controller **170** properly controls the movement of the grid **130**.

FIGS. **8A–8C** illustrate example operation screens presented on the operation display unit **230** in the imaging operation unit **220**.

Referring to FIG. **8A**, a touch panel **810** includes a liquid-crystal display and an analog resistive-film touch sensor sheet. A mouse **815** is used to move a pointer on the display screen or to select an item on the display screen. Designated as **820** are cables for power and control lines.

The touch panel **810** presents a display of imaging operational parameters. The imaging operational parameters are selected and input by either the touch panel **810** or the mouse **815** or a combination thereof. The cables **820** include a power cable, a VGA (Video Graphics Array) cable, a touch panel controlling serial cable, and a mouse serial cable.

An image display area **825** displays a captured X-ray image. An object information display area **830** displays information relating to the object. An imaging method object parameter display area **835** displays parameters of an imaging method object. An imaging method object display area **840** displays an imaging method object in response to a status of the apparatus. A message display area **845** displays status and messages of the apparatus or a system. A modification button **850** is used in case that imaging conditions and/or image processing parameters are modified.

When X-ray imaging, the operator selects a desired imaging method object from among the imaging method objects displayed in the imaging method object display area **840**. The selection of the imaging method object may be carried out by pressing the imaging method object displayed on the touch panel **810** or by sending the imaging information through the HIS/RIS system.

In the imaging method object, a number of imaging method parameters and standard imaging conditions corresponding to an imaging region are set. Since the standard exposure time t under the standard imaging conditions is associated with the grid table in one-to-one correspondence as already discussed with reference to FIG. **7**, the grid table is also set in the imaging method object. Specifically, when the operator selects the imaging method object, the standard imaging time (the standard exposure time) t set beforehand corresponding to the selected imaging method object is displayed, and the grid table $T_s \leqq T \leqq T_E$ responsive to the standard imaging time t is thus selected.

When the X-ray exposure button **210** is pressed with a "Ready" message displayed on the message display area **845**, the X-ray emitter **110** directs the X rays to the object **120**, thereby X-ray imaging of the object **120** is performed. During X-ray imaging, the grid movement controller **170** moves the grid **130** as shown in FIGS. **2**, **3**, and **5**.

When the object **120** is X-ray imaged in this way, the captured X-ray image is displayed on the image display area **825** as shown in FIG. **8B**. When the modification button **850** is pressed with the image method object selected as shown in FIG. **8B**, the display presented by the touch panel **810** changes to the one shown in FIG. **8C**.

Referring to FIG. **8C**, the touch panel **810** displays parameters required in X-ray imaging and sets those parameters corresponding to the selected imaging method object. The displayed parameters include exposure time, i.e., the standard exposure time. By modifying the exposure time using an up button or a down button, a grid table corresponding to a modified exposure time is displayed on the top portion of the screen.

In X-ray imaging, a function of adjusting a dose of X-ray irradiating the object, called an AEC (Auto Exposure

Control) function, is available. However, X-ray imaging must be performed with an exposure time matching a grid table to obtain an X-ray image free from a moire pattern due to the grid. Further, as described above, a grid table corresponding to the imaging method object needs to be set. Therefore, if an actual exposure time adjusted through the AEC fails to match the grid table (the exposure time defined by the grid table), the grid table needs to be modified to match the actual exposure time.

The operation of automatic adjustment of the grid table performed when the actual exposure time fails to match the grid table is discussed below.

FIG. **9** is a flow diagram showing the operation of the automatic adjustment of the grid table performed when the actual exposure time fails to match the grid table. This operation is performed by the imaging controller **180**.

When one imaging cycle is completed with the imaging method object selected, an actual exposure time T_X of the object **120** to the X rays is acquired from the X-ray emitter **110** or the X-ray timing acquisition unit **160** in step **S905**, and is stored as data. In step **S910**, the X-ray exposure time T_X acquired in step **S905** is grouped according to intervals that are predetermined by discretely subdividing the X-ray exposure time, and a frequency distribution of the X-ray exposure time is formed (updated). Specifically, one piece of data (a frequency of one) is added to the frequency distribution of the X-ray exposure time formed at a preceding imaging cycle, in accordance with those discrete intervals.

In step **S915**, the imaging controller **180** determines whether the number of imaging cycles, including this imaging cycle, is equal to or greater than N with the same imaging method object selected.

When it is determined that the number of imaging cycles is less than N, the imaging controller **180** determines that a correct (appropriate) grid table can not be presumed from the frequency distribution based on the past X-ray exposure time. The frequency distribution is not used, but the acquired X-ray exposure time T_X is used.

In step **S920**, the imaging controller **180** determines whether the currently acquired X-ray exposure time T_X falls within the range of the grid table $T_S \leqq T \leqq T_E$. When it is determined that the currently acquired X-ray exposure time T_X falls outside the range of the grid table $T_S \leqq T \leqq T_E$, the process proceeds to step **S925**. The imaging controller **180** newly selects a grid table $T_S \leqq T \leqq T \leqq T_E$ within which the X-ray exposure time T_X falls. This selection may be made so that the standard exposure time t discussed with reference to FIG. **7** equals the X-ray exposure time T_X, or so that a modification from the grid table $T_S \leqq T \leqq T_E$ for the current imaging is minimized.

When the new grid table is selected in step **S925**, the imaging controller **180** sets again the newly selected grid table to the imaging method object in step **S950**, and ends the process.

When it is determined in step **S920** that the currently acquired X-ray exposure time T_X falls within the range of the grid table $T_S \leqq T \leqq T_E$, the process ends without modifying the grid table (in step **S930**).

When it is determined in step **S915** that the number of imaging cycles is equal to or greater than N, the imaging controller **180** proceeds the process to step **S935** assuming that a correct grid table can be presumed from the frequency distribution based on the past X-ray exposure time.

The imaging controller **180** determines in step **S935** whether the total frequency of the frequency distribution is equal to or more than M. When the total frequency is equal to or more than M, data transnormal in the frequency distribution is deleted (for example, data of X-ray exposure time having the lowest frequency is deleted). In step **S940**, the imaging controller **180** determines whether the currently set grid table $\leqq T \leqq T_S T \leqq T_E$ is appropriate for the frequency distribution formed by the current imaging cycle. For example, in this determination, the imaging controller **180** references a difference between an expected value of the frequency distribution of the X-ray exposure time and the standard exposure time t shown in FIG. **7** currently set in the grid table, or performs a determination based on whether at least 80% elements of the frequency distribution satisfies the range of the grid table $T_S \leqq T \leqq T_E$. FIG. **10** shows an example of a frequency distribution.

When it is determined in step **S940** that the frequency distribution of the X-ray exposure time fails to satisfy the range of the currently set grid table $T_S \leqq T \leqq T \leqq T_E$, the process proceeds to step **S945**. The imaging controller **180** selects a grid table that meets the formed frequency distribution. In this selection, the imaging controller **180** selects a grid table, for example, so that an expected value of the frequency distribution of the X-ray exposure time substantially coincides with the standard exposure time t in the grid table shown in FIG. **7**, or so that at least 80% elements of the frequency distribution satisfies the range of the grid table $T_S \leqq T \leqq T_E$.

When the new grid table is selected in step **S945**, the newly selected grid table is set again to the imaging method object in step **S950**, and the process ends.

When it is determined in step **S940** that the frequency distribution of the X-ray exposure time satisfies the range of the currently set grid table $T_S \leqq T \leqq T_E$, the imaging controller **180** ends the process without modifying the grid table (in step **S930**).

As discussed above, while the X-ray emitter **110** directs the X rays to the object **120**, the grid movement controller **170** controls the movement of the grid **130** so that the reciprocatingly moving grid **130** moves in one direction with a higher probability. The X-ray image acquisition unit **150** detects the X rays transmitted through the object **120** and the grid **130**, and acquires an X-ray image in response to the intensity of the detected X rays.

Accordingly, the probability that when the grid **130** turns and moves the object **120** is still exposed to the X rays from the X-ray emitter **110** is reduced. In this way, the probability that the X-ray image acquisition unit **150** presents an X-ray image having less or no moire pattern due to the grid **130** is heightened.

The X-ray timing acquisition unit **160** measures the actual duration of time during which the object **120** is exposed to the X rays from the X-ray emitter **110**. Based on the measured time, the configuration is provided that the grid movement controller **170** controls the movement of the grid **130** to increase the probability that the grid **130** moves in one direction during X-ray exposure (irradiation) time. In this way, the grid **130** is controlled at an appropriate speed and timing. Thus the probability that the X-ray image acquisition unit **150** provides an X-ray image with less or no moire pattern is heightened.

A standard time for exposing the object **120** to the X rays and/or an effective time duration including the standard exposure time are set as an X-ray exposure time. Parameters, such as the grid movement speed that is determined based on the X-ray exposure time, are set as the grid table for controlling the movement of the grid **130**. The grid move-

ment controller **170** thus controls the movement of the grid **130** in accordance with the grid table. By simply moving the grid **130** in accordance with the grid table, the probability that the reciprocatingly moving grid **130** moves in one direction during X-ray irradiation and that the X-ray image acquisition unit **150** acquires an X-ray image having less or no moire pattern due to the grid **130** is heightened.

Since the grid table used in X-ray imaging is displayed on the operation display unit **230**, the operator judges from the actual X-ray exposure time whether an image with less or no moire pattern due to the grid **130** has been obtained. When the operator sets X-ray exposure time beforehand and radiographs the object **120**, the operator has a chance, by the displayed grid table, to set an X-ray exposure time with which the probability that an image with less or no moire pattern due to the grid **130** is obtained is heightened.

Since a grid table is preset for each imaging method object displayed on the imaging operation unit **220**, the operator easily selects the grid table that is preset appropriately for radiographing each region of an object, by simply selecting the imaging method object. This arrangement saves the labor time an operator may take to consider and then select the grid table at each imaging cycle.

The standard exposure time t is set to subdivide the time interval between the minimum X-ray exposure time T_S and the maximum X-ray exposure time T_E by a ratio of m:n (m and n are natural numbers), and the grid table is selected based on the standard exposure time t. When presetting the grid table for the imaging method object, the operator easily presets the grid table using the standard exposure time t as a guideline.

If the grid table set in each imaging method object is determined to fail to satisfy the actual X-ray exposure time (from statistics of past X-ray exposure times), the grid table satisfying the X-ray exposure time during imaging is automatically selected. The selected grid table is again set in the imaging method object. Even if a proper grid table is not set in one of score of imaging types, a grid table, which may be inappropriate, is replaced with another appropriate grid table which is considered more appropriate from the statistics of past X-ray exposure times.

The present invention has been discussed in connection with the digital radiographic apparatus using X-ray. However, the present invention is not limited to apparatuses using X rays. The present invention is applicable to apparatuses which obtain object images using other radiation transmitted by the object.

Modifications of the Embodiment of the Present Invention

A program code of software for carrying out the functions of the invention can be loaded into a computer in a system or an apparatus connected to a variety of devices so that the devices perform the functions of the invention. The variety of devices operate in accordance with the program stored in the computer (CPU or MPU) in the system or apparatus. The functions and process steps of the invention are thus carried out. Such embodiments fall within the scope of the present invention.

The program code of software performs the functions and the process steps of the invention. The program code itself, and means for feeding the program code to the computer, for example, a storage medium for storing the program code, fall within the scope of the present invention.

Available as storage media for storing the program code are a floppy disk, a hard disk, an optical disk, a magneto-optical disk, a CD-ROM, a magnetic tape, a nonvolatile memory card, ROM and the like.

By executing the program code read by the computer, the computer realizes the functions or performs the process steps of the invention. Furthermore, the functions or the process steps of the invention are realized or performed in cooperation with the OS (operating system) running on the computer or another application software program according to the instruction of the program code. Such a program code falls within the scope of the present invention.

The program code is read into a memory incorporated in a function expansion board in the computer or in a function expansion unit connected to the computer. The CPU mounted on the function expansion board or the function expansion unit performs partly or entirely the actual process in response to the instruction from the program code. The functions or the process steps of the invention are realized or executed through the process. Such a program code falls within the scope of the present invention.

The program code is delivered in a computer-readable storage medium. The program code may also be delivered on-line through a communication network such as the Internet.

While the present invention has been described with reference to what are presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

What is claimed is:

1. An apparatus for radiographing an object, comprising:

an X-ray radiation unit for radiating X-ray;

a grid arranged in an X-ray radiation path;

a grid movement controller for changing a movement speed of the grid by changing a turn speed of a motor, comprising a link mechanism for changing a turn movement of the motor into a straight movement of the grid;

a sensor unit for converting the X-ray into image data;

an input unit for inputting information relating to a region of a body; and

an imaging controller for controlling (i) the time for the X-ray radiation unit to start radiating the X-ray, (ii) the time for the grid movement controller to start rotating the motor, and (iii) the time for the sensor unit to start storage, by associating one with another,

wherein the imaging controller (a) selects a standard radiation exposure time and the turn speed based on the information input into the input unit, (b) controls the radiation exposure starting time of the X-ray radiation unit based on the selection, and (c) causes the grid movement controller to rotate the motor at the turn speed,

wherein the standard radiation exposure time is selected based on the maximum X-ray radiation time to be determined according to the region of the body, and

wherein the imaging controller is configured such that it controls the radiation exposure starting time of the X-ray radiation unit so that the standard radiation exposure time will be y divided by a ratio of m:n, where y is the time interval between the minimum X-ray radiation time and the maximum X-ray radiation time, m and n are natural numbers, and the minimum X-ray radiation time and the maximum X-ray radiation time are determined according to the region of the body.

2. An apparatus according to claim 1, wherein the minimum X-ray radiation time is the time from when radiation starts until when the grid moves a predetermined distance, and the maximum X-ray radiation time is the time from when radiation starts until when the grid starts a turn movement.

3. An apparatus according to claim 2, wherein the predetermined distance is determined so that the value of the predetermined distance multiplied by a pitch of a lead foil of the grid will be a predetermined value.

4. An apparatus according to claim 1, further comprising a display unit for displaying one or more combinations of the minimum X-ray radiation time and the maximum X-ray radiation time, and the standard radiation exposure time.

5. An apparatus according to claim 1, wherein m is 5 and n is 2, and wherein the standard radiation exposure time is y/(5/2).

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,795,528 B2
APPLICATION NO. : 10/035154
DATED : September 21, 2004
INVENTOR(S) : Makoto Nokita

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

COLUMN 2
Line 3, “is” should read --are--.

COLUMN 10
Line 35, “parameters and” should read --parameters, especially--.
Line 36, “region” should read --region,--.
Line 39, “FIG. 7,” should read --FIG. 7, information concerning--.
Line 45, “thus selected” should read --also selected--.
Line 52, “X-ray imaged” should read --radiographed--.
Line 53, “image is” should read --image and the test conditions 875 corresponding to the image are--.
Line 55, “image method” should read --imaging method--.

COLUMN 11
Line 46, “$T_S \leqq T \leqq T \leqq T_E$” should read --$T_S \leqq T \leqq T_E$--.

COLUMN 12
Line 18, “$T_S \leqq T \leqq T \leqq T_E$,” should read --$T_S \leqq T \leqq T_E$,--.
Line 45, “moves” should read --moves,--.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,795,528 B2
APPLICATION NO. : 10/035154
DATED : September 21, 2004
INVENTOR(S) : Makoto Nokita

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

<u>COLUMN 13</u>
Line 32, “set in” should read --preset for--.
Line 32, “object is” should read --object--.
Line 33, “determined to fail” should read --fails--.
Line 34 “(from statistics” should read --(this unsatisfaction is determined from statistics--.
Line 36 “selected” should read --newly-selected--.
Line 36, “set in” should read --set for--.
Line 37, “not set” should read --not preset--.
Line 38, “score” should read --scores--.
Line 39, “another appropriate” should read --another--.

Signed and Sealed this

Twenty-sixth Day of February, 2008

Jon W. Dudas

JON W. DUDAS
Director of the United States Patent and Trademark Office

US005675755A

United States Patent [19]

Trueblood

[11] **Patent Number: 5,675,755**

[45] **Date of Patent: Oct. 7, 1997**

[54] **WINDOW SYSTEM PREVENTING OVERLAP OF MULTIPLE ALWAYS-VISIBLE WINDOWS**

[75] Inventor: **John Warren Trueblood**, San Diego, Calif.

[73] Assignees: **Sony Corporation**, Tokyo, Japan; **Sony Electronics, Inc.**, Park Ridge, N.J.

[21] Appl. No.: **482,184**

[22] Filed: **Jun. 7, 1995**

[51] **Int. Cl.**[6] **G06F 3/00**

[52] **U.S. Cl.** **395/346**; 395/342; 395/344

[58] **Field of Search** 395/155–161, 395/326–358; 345/117–120

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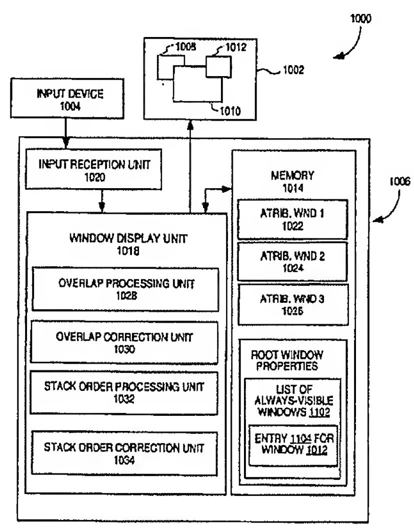
Primary Examiner—John E. Breene

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] **ABSTRACT**

A method and apparatus for establishing an always-visible class of windows in a computer-implemented windowing environment is provided. A user may designate one or more windows as always-visible windows. If an always-visible window overlaps with a non-always-visible window, then the always-visible window is displayed on top of the non-always-visible window. Always-visible windows are prevented from overlapping with each other. Techniques are provided for implementing the always-visible window class in a manner that complies with the X Windows system. According to one technique, the override redirect attribute is used as a flag to designate which windows are always-visible windows. According to an alternative technique, a list of always-visible windows is maintained as a property attached to a root window.

21 Claims, 18 Drawing Sheets



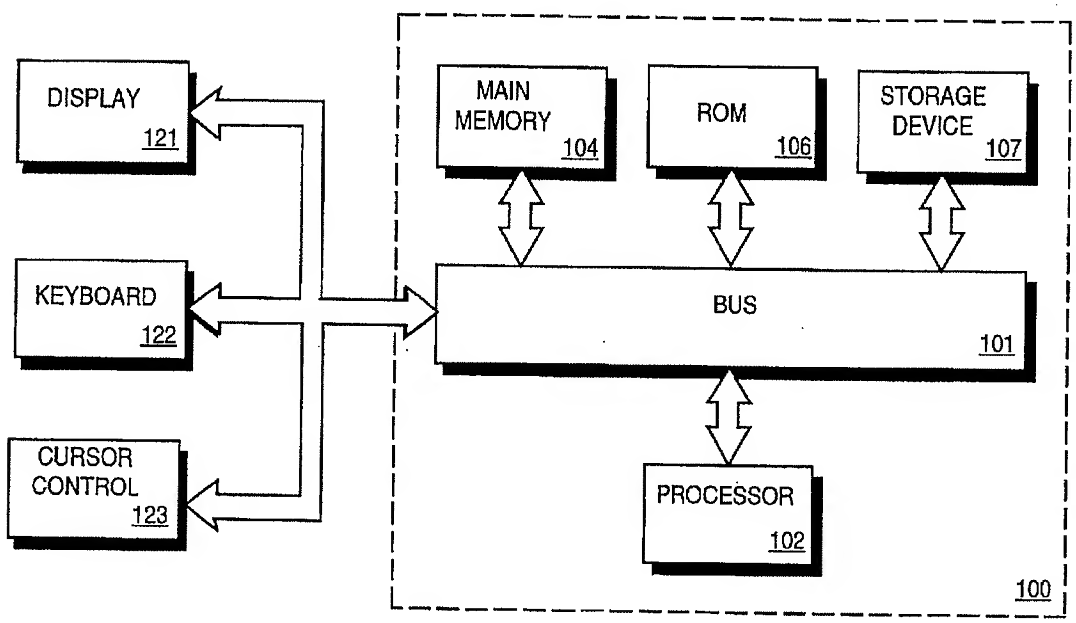

DISPLAY
121
KEYBOARD
122
CURSOR CONTROL
123
MAIN MEMORY
104
ROM
106
STORAGE DEVICE
107
BUS
101
PROCESSOR
102
100

Fig. 1

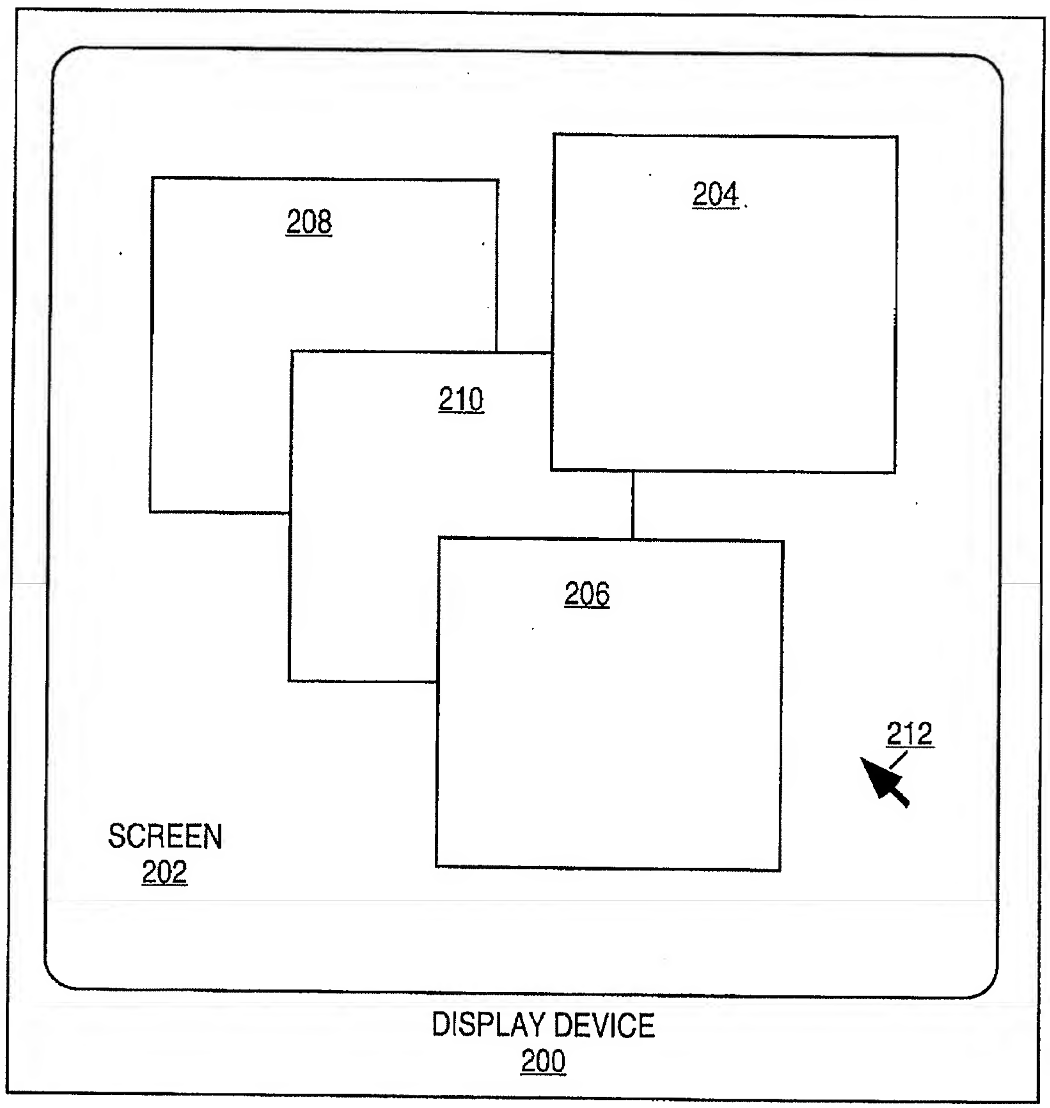


Fig. 2

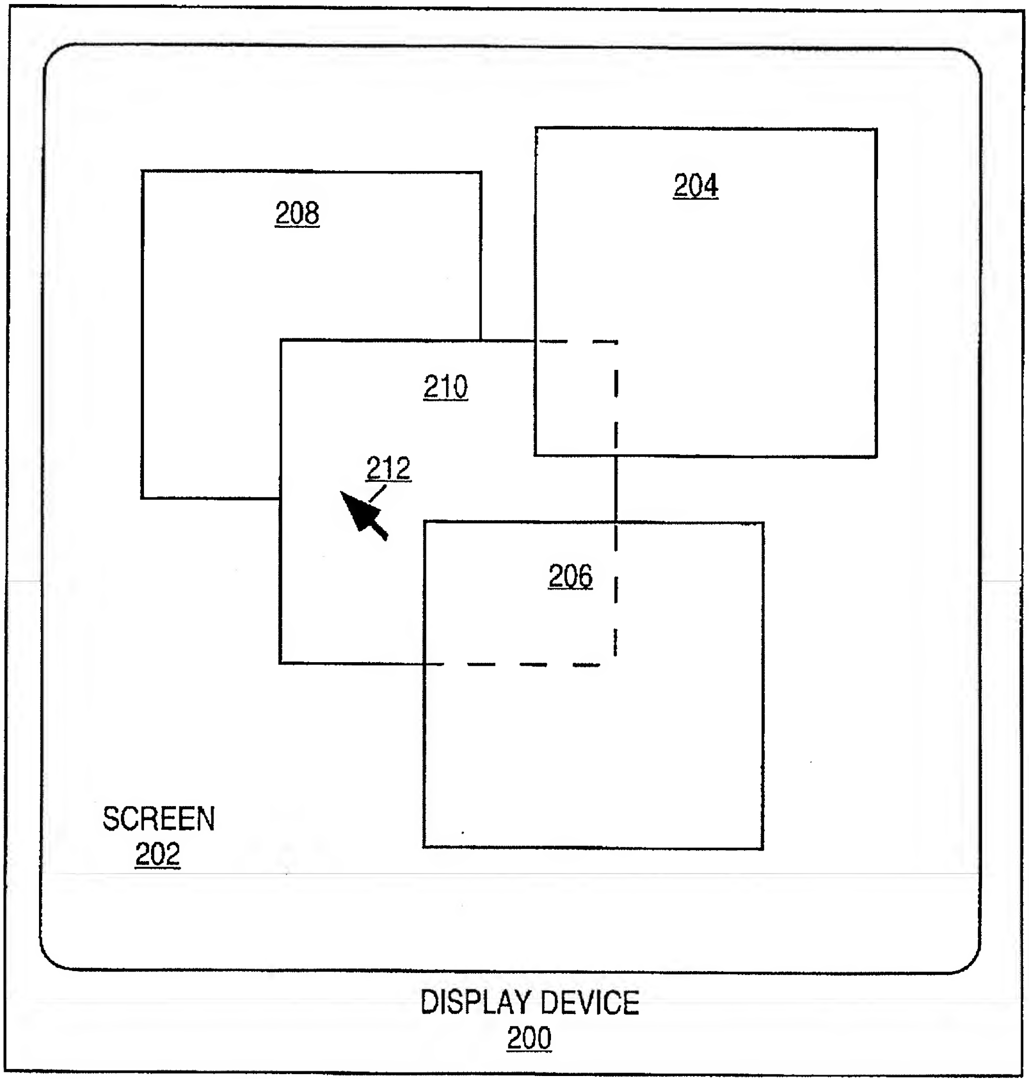


Fig. 3

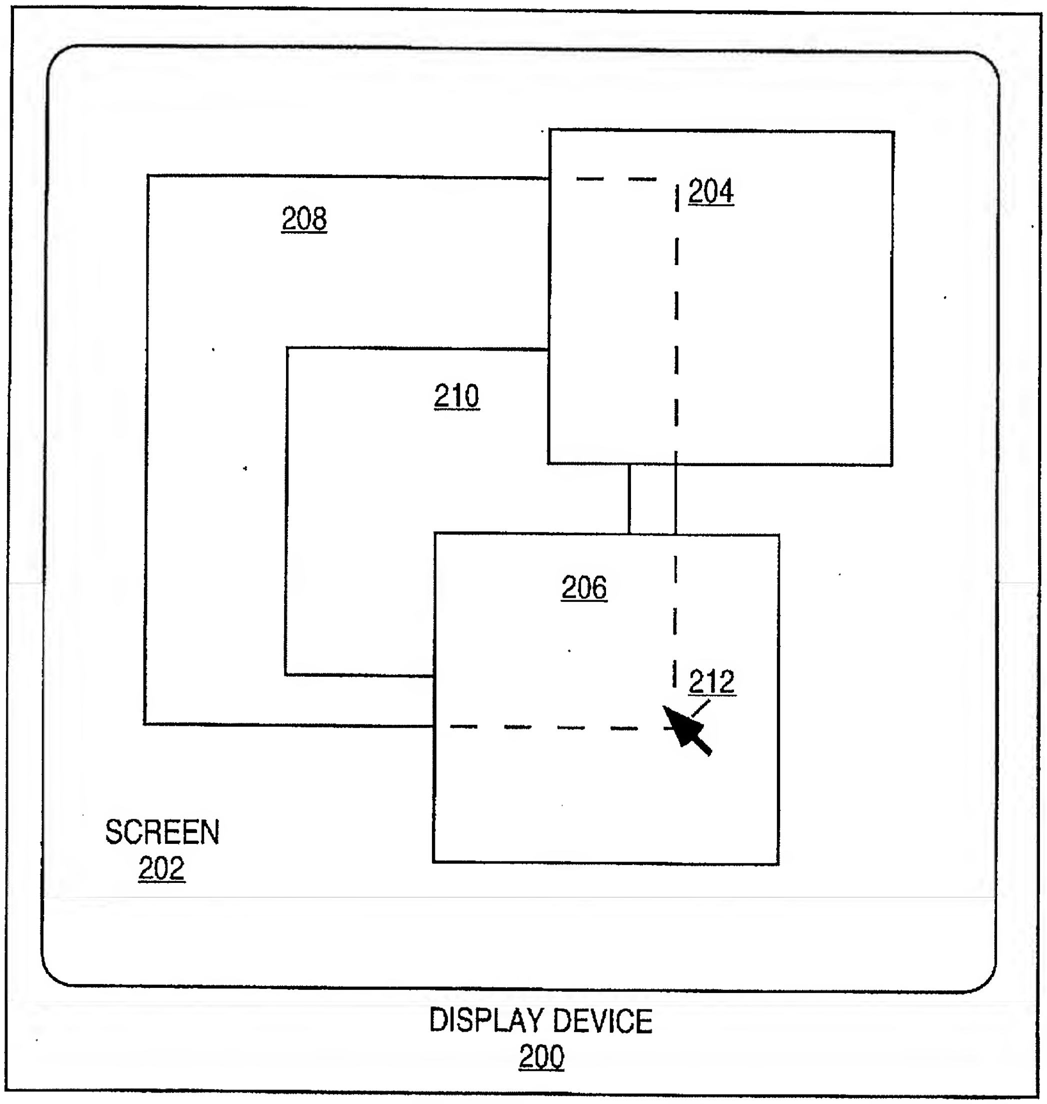


Fig. 4

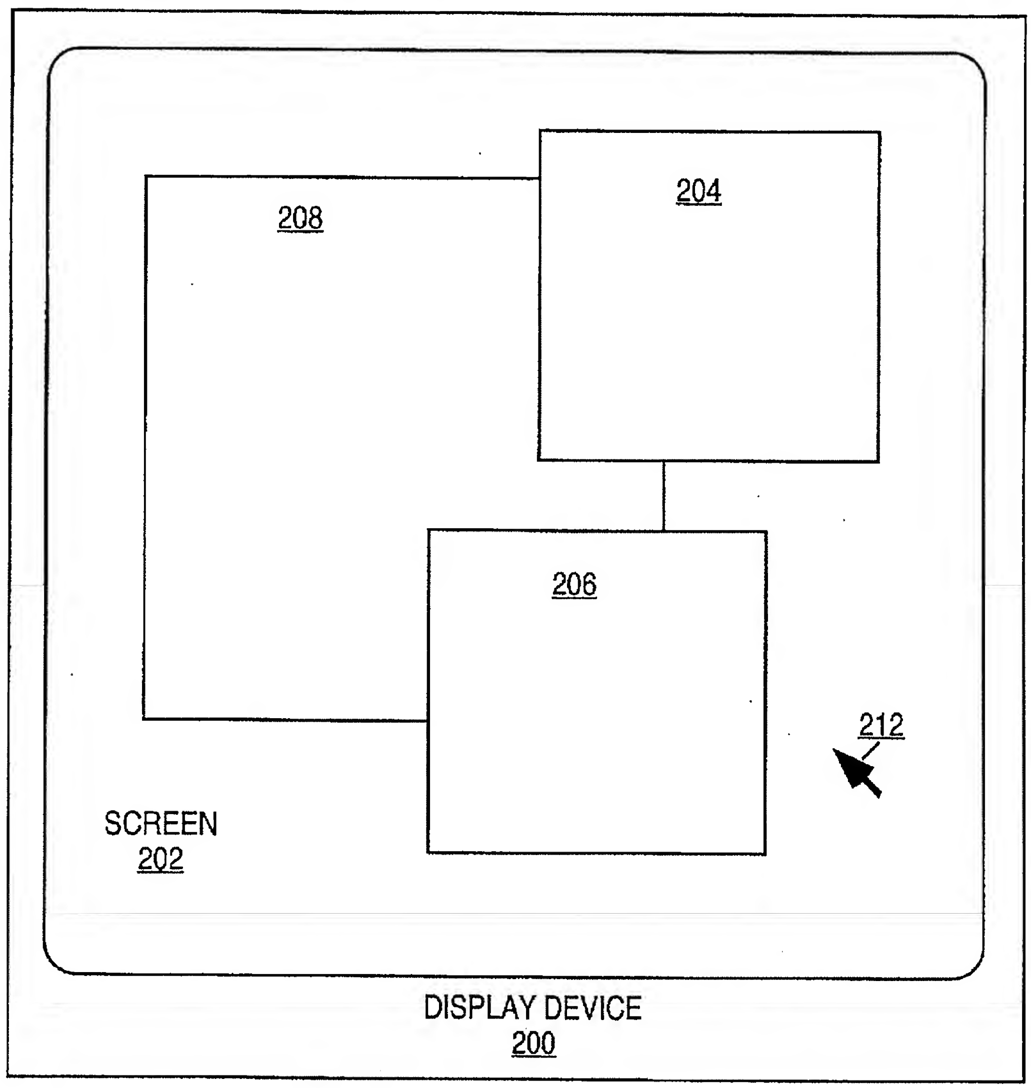


Fig. 5

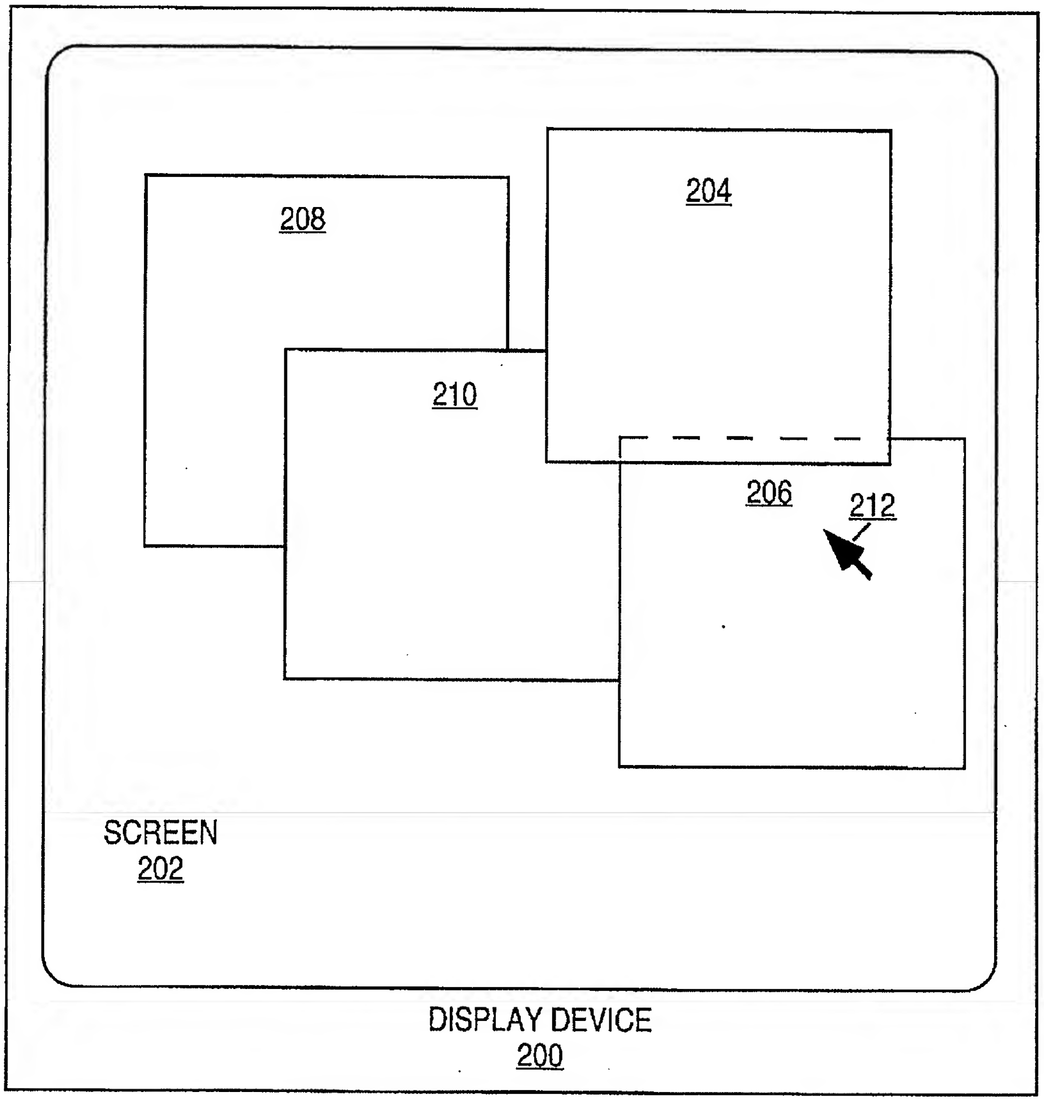


Fig. 6

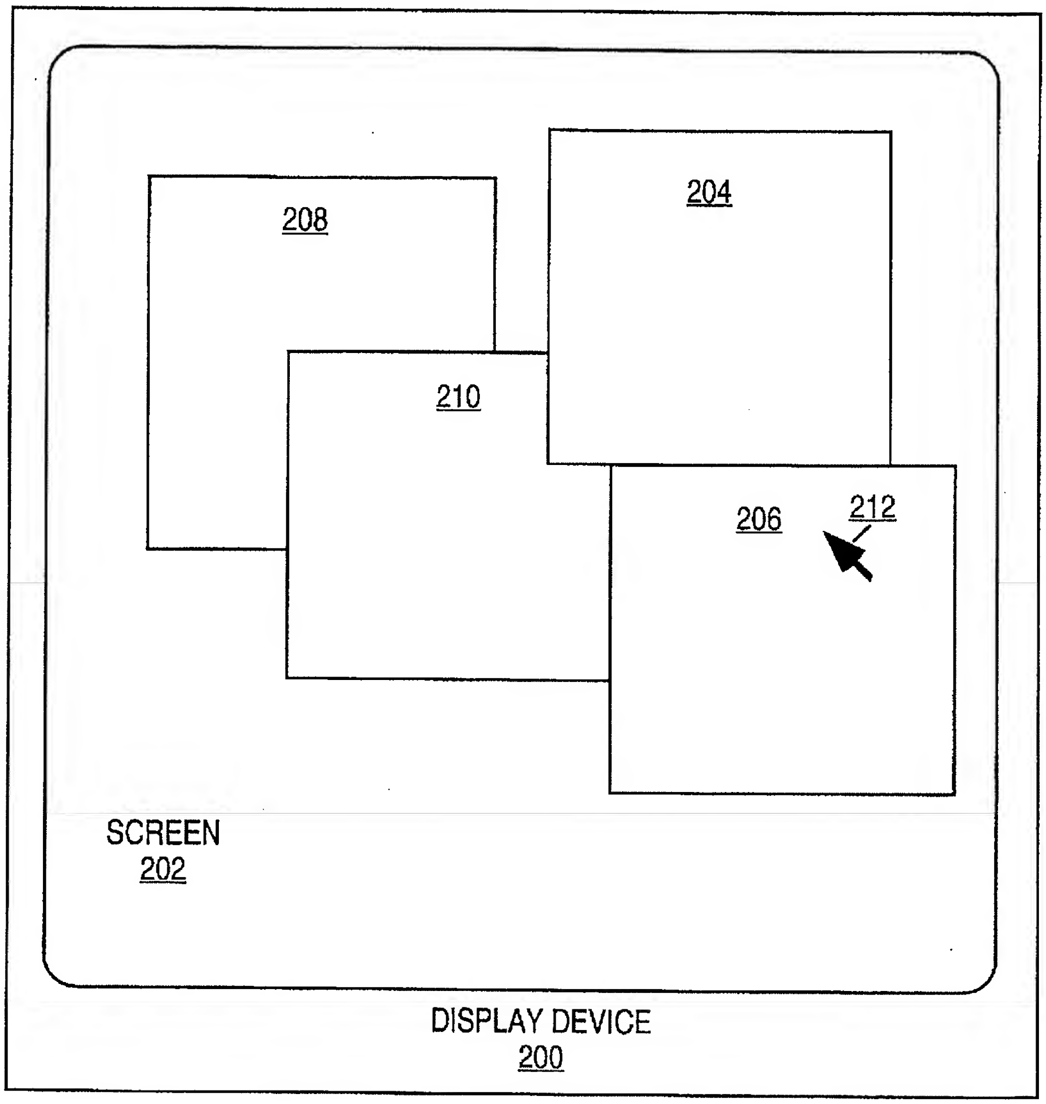


Fig. 7

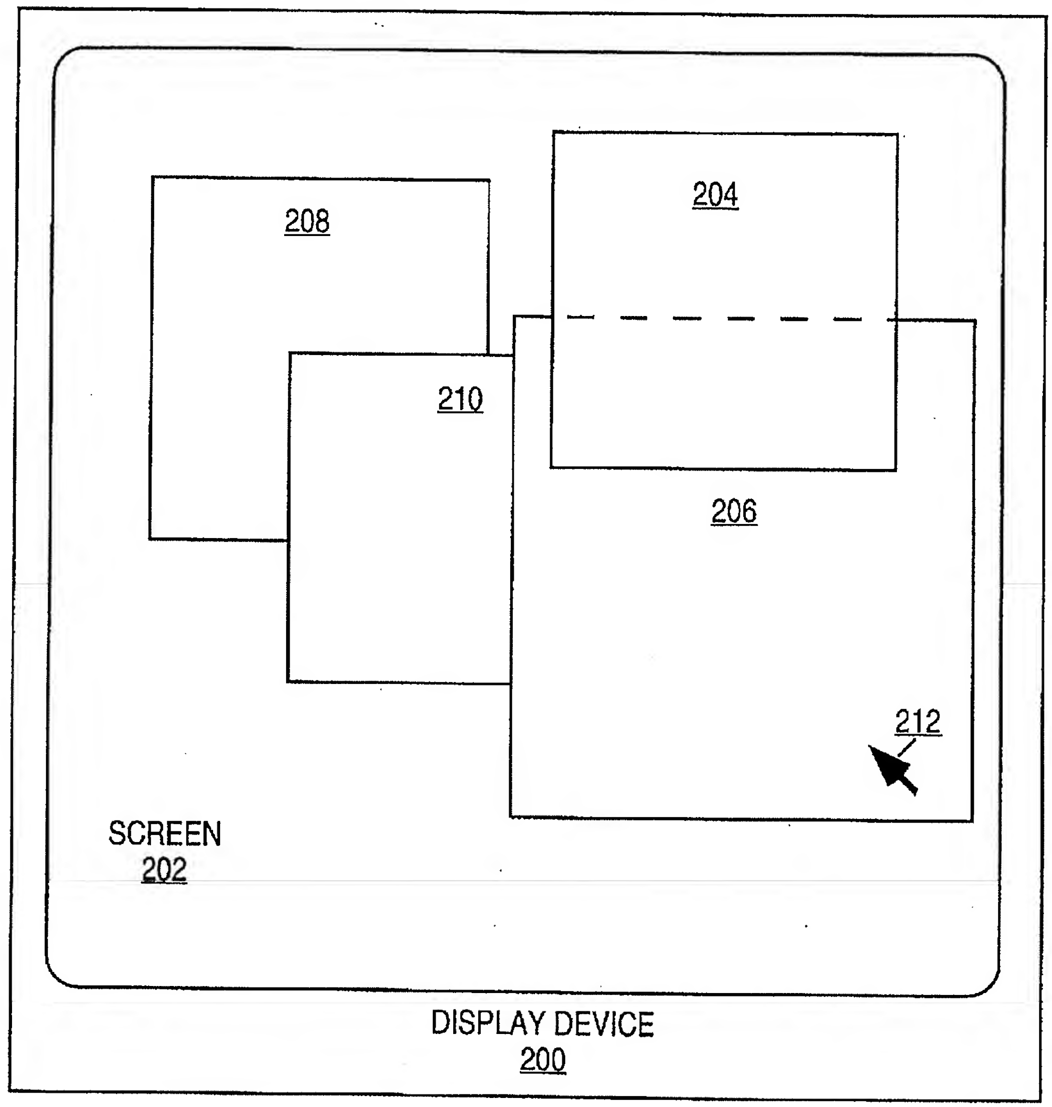


Fig. 8

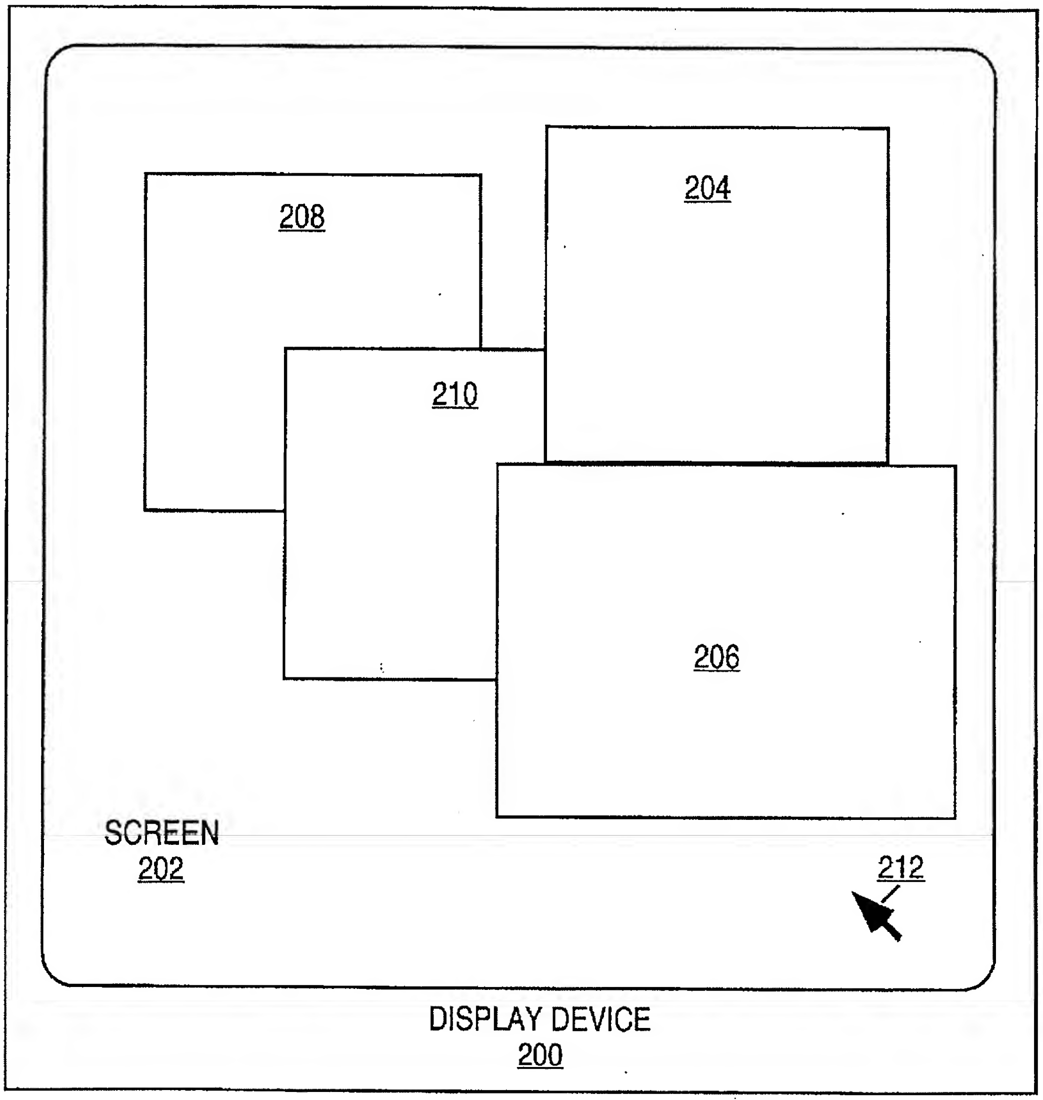
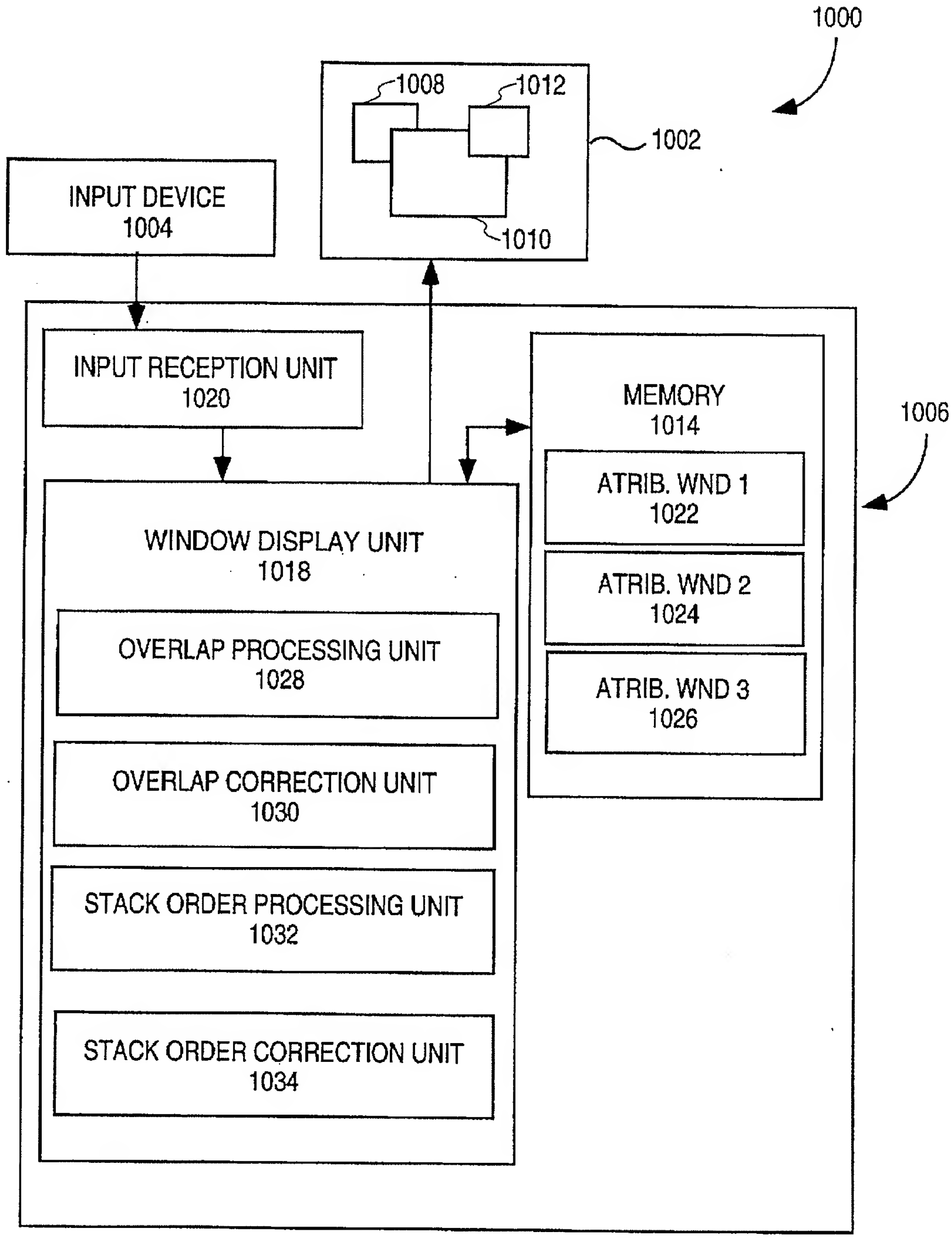


Fig. 9



1000
1008
1012
1002
1010
INPUT DEVICE
1004
INPUT RECEPTION UNIT
1020
MEMORY
1014
1006
ATRIB. WND 1
1022
ATRIB. WND 2
1024
ATRIB. WND 3
1026
WINDOW DISPLAY UNIT
1018
OVERLAP PROCESSING UNIT
1028
OVERLAP CORRECTION UNIT
1030
STACK ORDER PROCESSING UNIT
1032
STACK ORDER CORRECTION UNIT
1034

Fig. 10

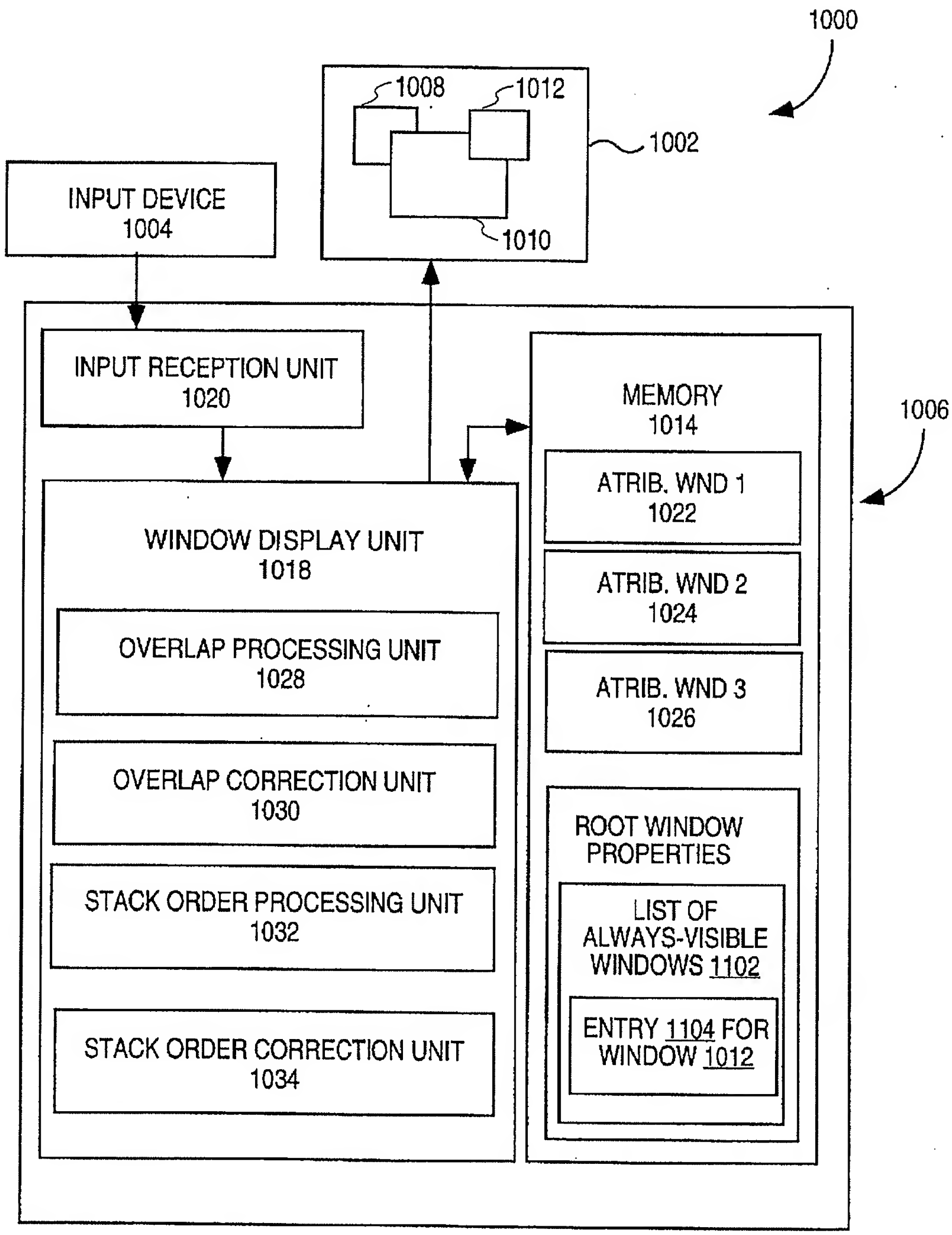

1000
1008
1012
1002
1010
INPUT DEVICE
1004
INPUT RECEPTION UNIT
1020
MEMORY
1014
1006
ATRIB. WND 1
1022
ATRIB. WND 2
1024
ATRIB. WND 3
1026
WINDOW DISPLAY UNIT
1018
OVERLAP PROCESSING UNIT
1028
OVERLAP CORRECTION UNIT
1030
STACK ORDER PROCESSING UNIT
1032
STACK ORDER CORRECTION UNIT
1034
ROOT WINDOW PROPERTIES
LIST OF ALWAYS-VISIBLE WINDOWS 1102
ENTRY 1104 FOR WINDOW 1012

Fig. 11

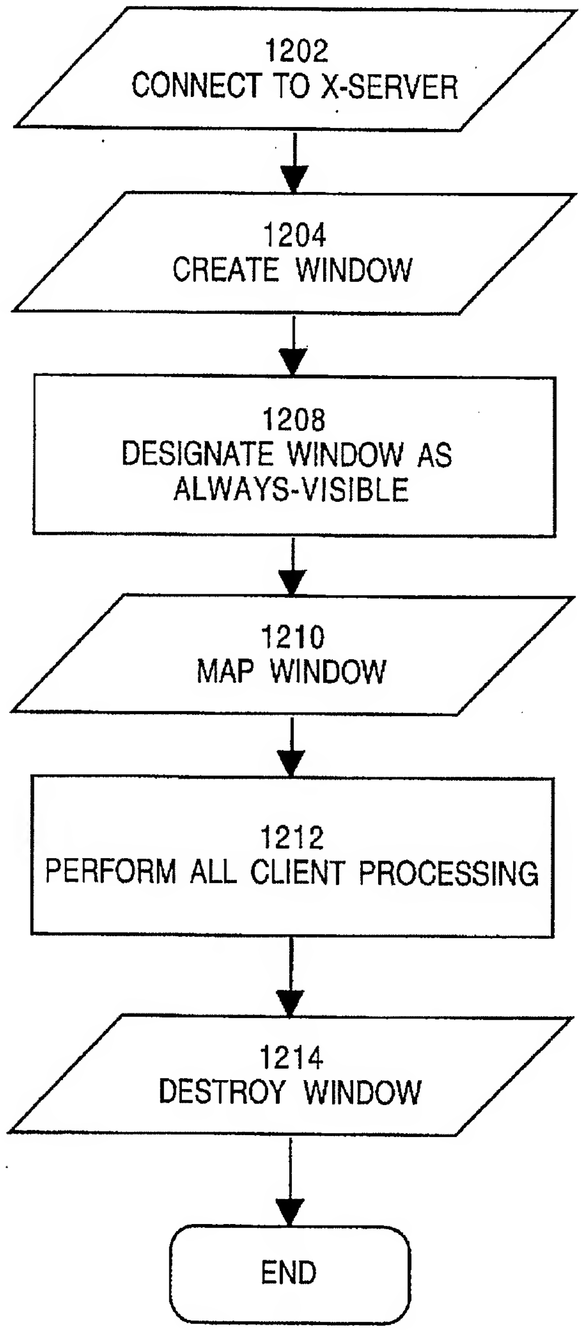

1202
CONNECT TO X-SERVER
1204
CREATE WINDOW
1208
DESIGNATE WINDOW AS ALWAYS-VISIBLE
1210
MAP WINDOW
1212
PERFORM ALL CLIENT PROCESSING
1214
DESTROY WINDOW
END

Fig. 12A

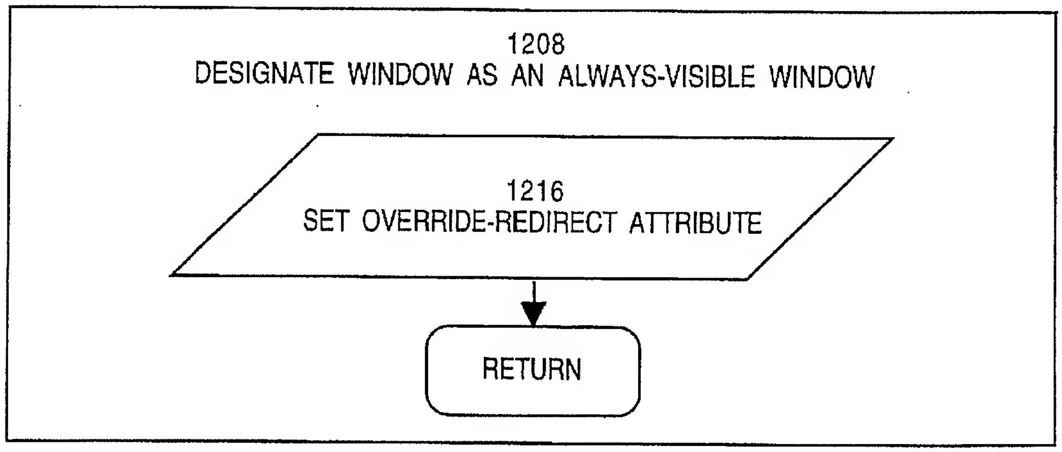


Fig. 12B

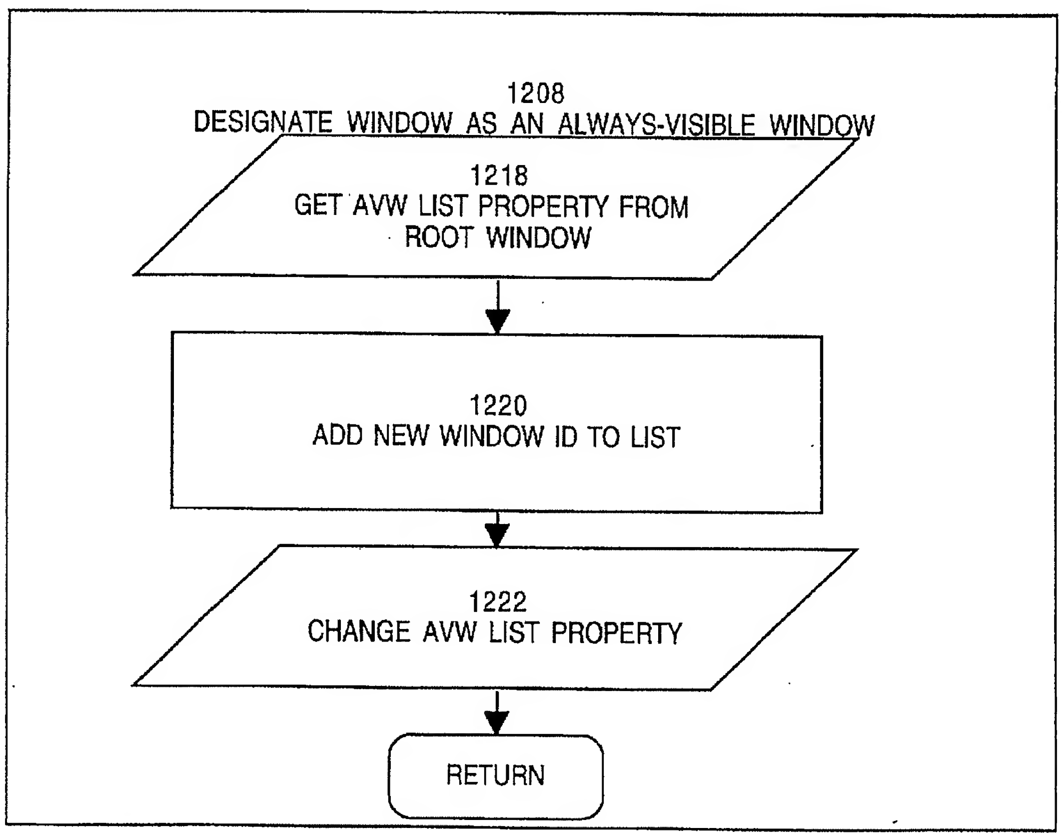


Fig. 12C

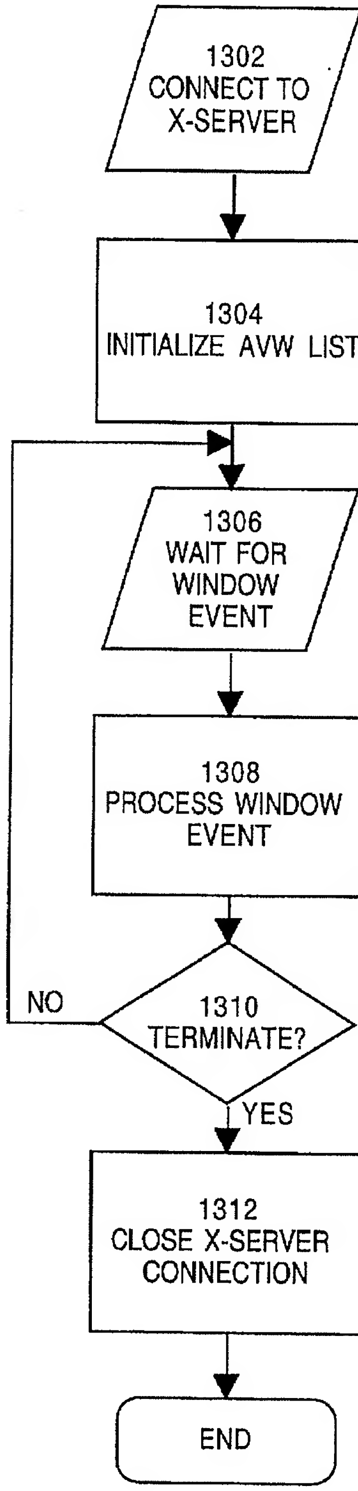

1302
CONNECT TO
X-SERVER
1304
INITIALIZE AVW LIST
1306
WAIT FOR
WINDOW
EVENT
1308
PROCESS WINDOW
EVENT
NO
1310
TERMINATE?
YES
1312
CLOSE X-SERVER
CONNECTION
END

Fig. 13A

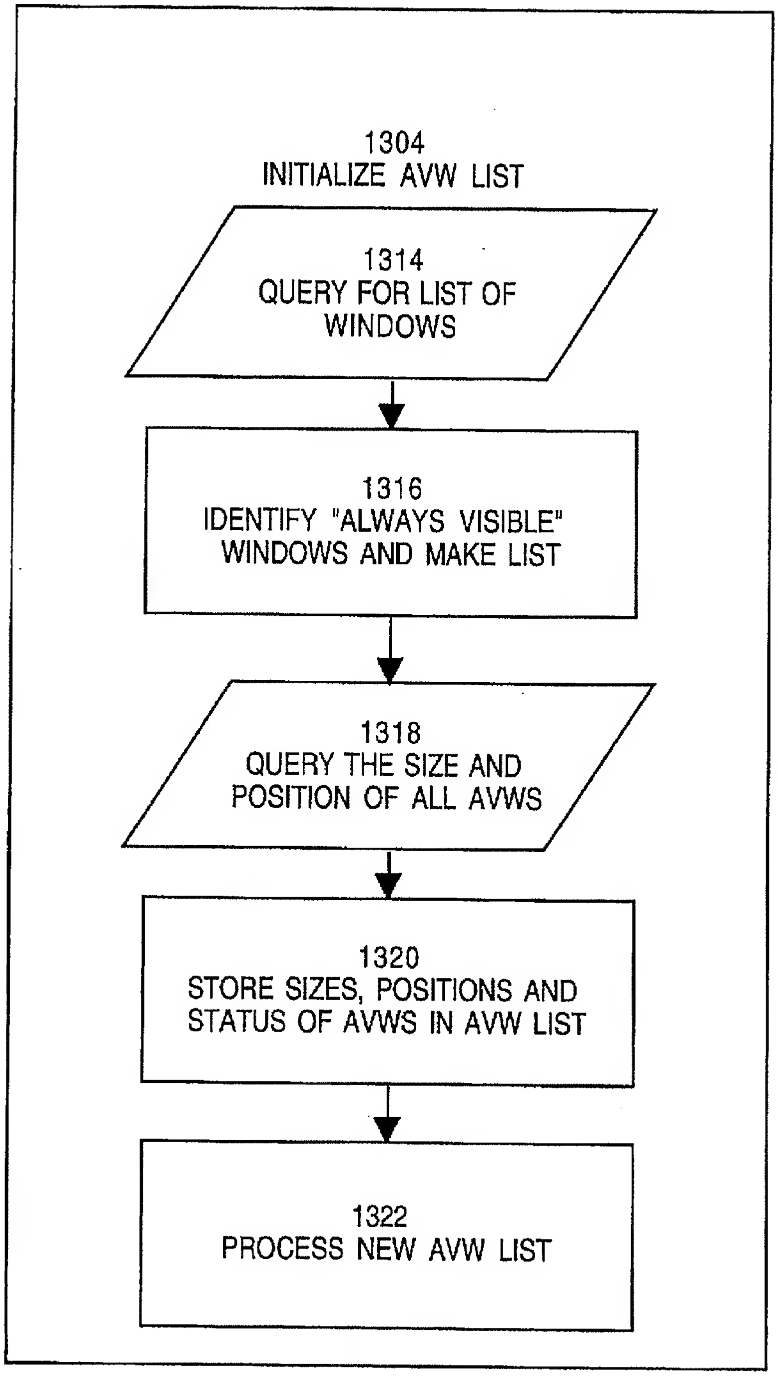

1304
INITIALIZE AVW LIST
1314
QUERY FOR LIST OF WINDOWS
1316
IDENTIFY "ALWAYS VISIBLE" WINDOWS AND MAKE LIST
1318
QUERY THE SIZE AND POSITION OF ALL AVWS
1320
STORE SIZES, POSITIONS AND STATUS OF AVWS IN AVW LIST
1322
PROCESS NEW AVW LIST

Fig. 13B

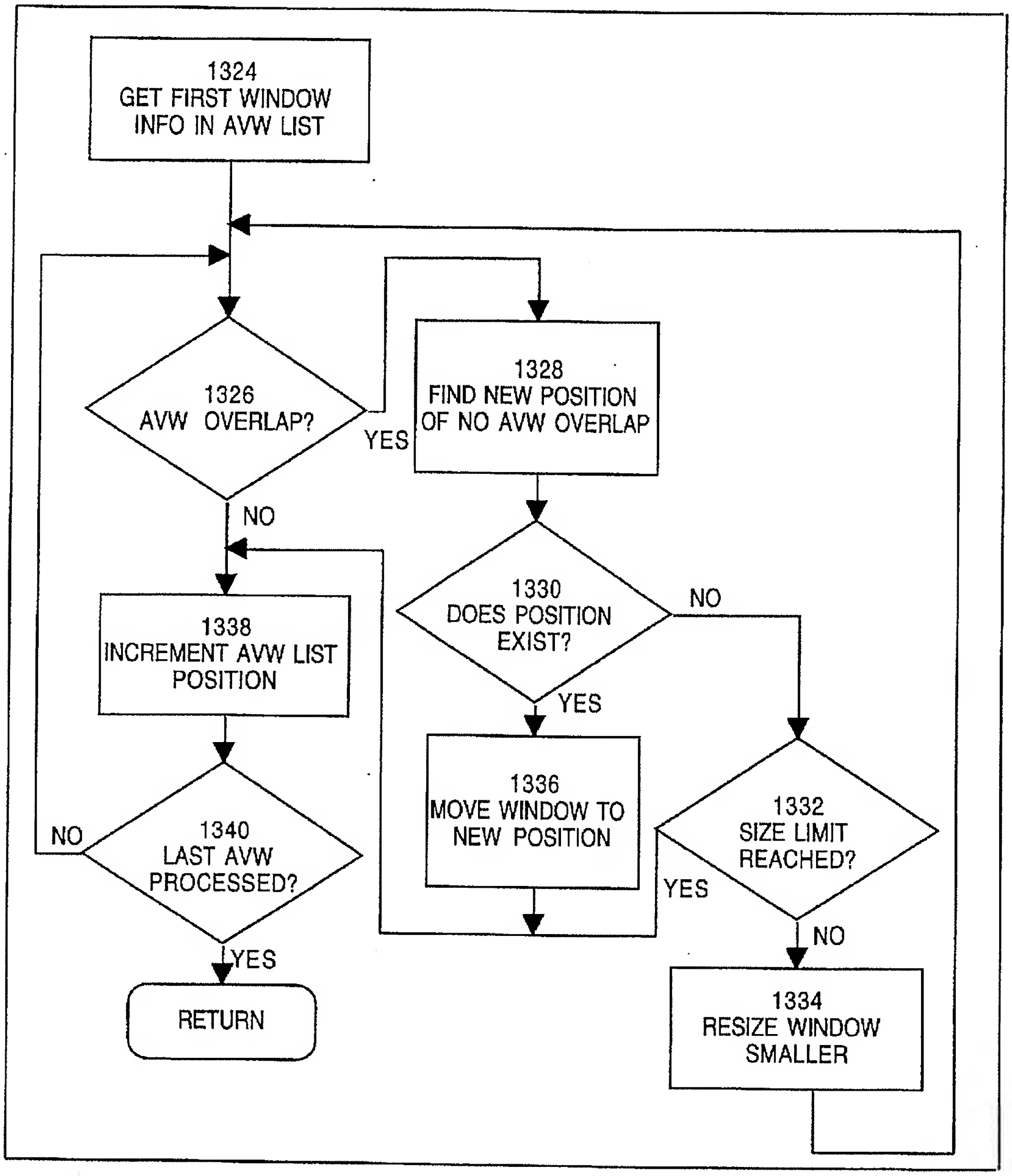

1324
GET FIRST WINDOW INFO IN AVW LIST
1326
AVW OVERLAP?
YES
NO
1328
FIND NEW POSITION OF NO AVW OVERLAP
1330
DOES POSITION EXIST?
NO
YES
1338
INCREMENT AVW LIST POSITION
1336
MOVE WINDOW TO NEW POSITION
1332
SIZE LIMIT REACHED?
YES
NO
1340
LAST AVW PROCESSED?
NO
YES
RETURN
1334
RESIZE WINDOW SMALLER

Fig. 13C

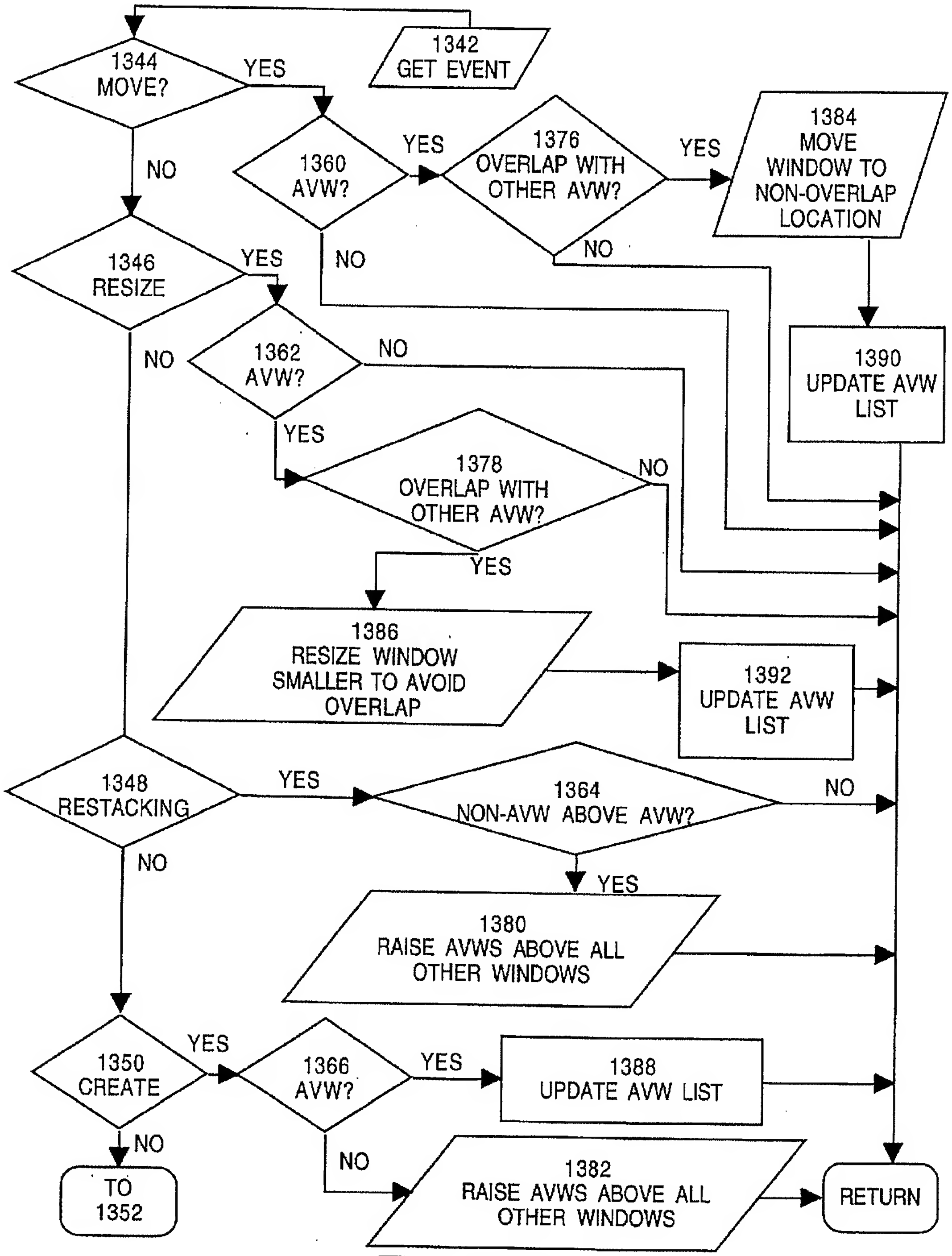

1342
GET EVENT
1344
MOVE?
YES
NO
1360
AVW?
YES
NO
1376
OVERLAP WITH
OTHER AVW?
YES
NO
1384
MOVE
WINDOW TO
NON-OVERLAP
LOCATION
1390
UPDATE AVW
LIST
1346
RESIZE
YES
NO
1362
AVW?
NO
YES
1378
OVERLAP WITH
OTHER AVW?
NO
YES
1386
RESIZE WINDOW
SMALLER TO AVOID
OVERLAP
1392
UPDATE AVW
LIST
1348
RESTACKING
YES
NO
1364
NON-AVW ABOVE AVW?
NO
YES
1380
RAISE AVWS ABOVE ALL
OTHER WINDOWS
1350
CREATE
YES
NO
1366
AVW?
YES
NO
1388
UPDATE AVW LIST
TO
1352
1382
RAISE AVWS ABOVE ALL
OTHER WINDOWS
RETURN

Fig. 13D

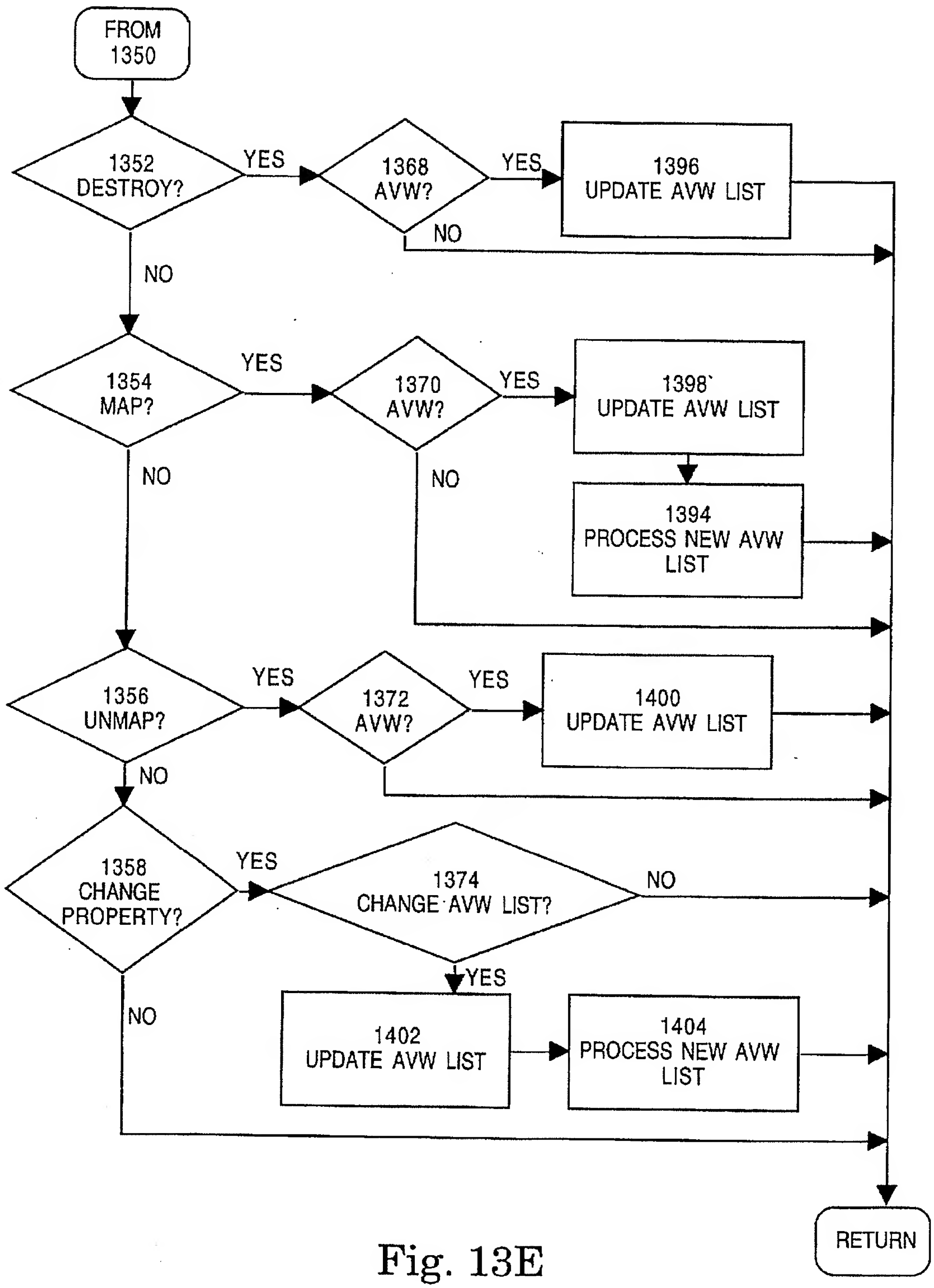

FROM 1350
1352 DESTROY?
YES
1368 AVW?
YES
1396 UPDATE AVW LIST
NO
NO
1354 MAP?
YES
1370 AVW?
YES
1398 UPDATE AVW LIST
NO
NO
1394 PROCESS NEW AVW LIST
1356 UNMAP?
YES
1372 AVW?
YES
1400 UPDATE AVW LIST
NO
1358 CHANGE PROPERTY?
YES
1374 CHANGE AVW LIST?
NO
YES
NO
1402 UPDATE AVW LIST
1404 PROCESS NEW AVW LIST
RETURN

Fig. 13E

WINDOW SYSTEM PREVENTING OVERLAP OF MULTIPLE ALWAYS-VISIBLE WINDOWS

FIELD OF THE INVENTION

The present invention relates to window management on computer systems, and more specifically, to a method and apparatus for displaying a class of always-visible windows in an X Windows system.

BACKGROUND OF THE INVENTION

A window is a user interface object that establishes a correlation between a particular set of data and a particular screen region. Unless the window is hidden or covered by another user interface object, the set of data is typically displayed in the corresponding screen region. The use of windows has proven to be an effective way of communicating information to a computer user. For example, a word processing system that allows a user to open multiple documents may provide a separate window for displaying the contents of each of the open documents.

For added flexibility, many window management systems allow windows to overlap with each other. Two windows overlap when there is an intersection between the screen regions associated with the windows. If the contents of two or more overlapping windows are displayed in the common screen region, the information may appear garbled and difficult to read. Consequently, the window management system must determine what should be displayed in the region that is common to overlapping windows.

To address this problem raised by overlapping windows, most window management systems assign each window a position in a "stack order". When multiple windows share the same screen region, only the information from the window that has the higher position in the stack order is shown in the screen region. Thus, the portion of the lower-ordered window that corresponds to the common screen region will be "covered" by the portion of the higher-ordered window that corresponds to the common screen region. To a user, this makes the lower-ordered window appear as if it were physically below the higher-ordered window.

Most window management systems allow users to move, resize and change the stack order of individual windows. For example, in the System 7 operating system available from Apple Computer, Inc., a window assumes the highest position in the stack order when a user clicks on a portion of the window using an input device such as a mouse or trackball. A window is resized by dragging the bottom corner of the window until the window has the desired dimensions. A window is moved by dragging the title bar of the window to a new position on the screen display.

In some applications, it may be important to ensure that certain information is always visible to the user. However, if the information is displayed in a window in a system that allows windows to overlap, then the vital information may become hidden from the user. For example, the information may become covered if the user performs some action that would cause a window that is higher in the stack order to overlap with the given window. Numerous types of user actions can cause this situation to arise. For example, the user may cause an already-overlapping window to assume a position in the stack order that is higher than the position of the given window. Alternatively, the user may move a window that is already higher in the stack order to a screen position that overlaps with the given window.

Various attempts have been made to prevent important information displayed in a window from becoming hidden to

the user. For example, PC Tools for Windows provides a window-based graphical desktop that allows a user to specify that a window should remain "always on top". The "always on top" window is assigned a position in the stack order that is higher than the highest position assigned to ordinary windows. Consequently, if any window is manipulated in such a way as to overlap with the "always on top" window, the overlapping portion of the "always on top" window will cover the other window in the common screen region.

This approach works well as long as there is only one window that contains crucial information. However, a problem arises when more than one "always on top" window is needed. In PC Tools for Windows, if two windows are designated as "always on top" windows, they behave the same with respect to each other as normal windows do with respect to each other. That is, one "always on top" window will have a higher stack order position than the other. When the two "always on top" windows are caused to overlap, the higher-ordered window will cover the lower-ordered window in the common screen region. The information contained in the covered portion of the lower-ordered window is no longer visible to the user. Thus, when more than one "always on top" window is displayed, there is no way to ensure that critical information will always be visible to the user.

One way to avoid this problem is to allow only one "always on top" window at a time. For example, French Patent Publication number 2,693,810 describes a window management system that provides one window that cannot be obscured by other windows. When a user designates a second window as a non-obscurable window; the first non-obscurable window ceases to be non-obscurable. Because this system does not support multiple non-obscurable windows, its utility is limited.

Based on the foregoing, it is clearly desirable to provide a windowing system that allows information to be simultaneously displayed in multiple always-visible windows. Further, it is desirable to provide an always-visible class of windows in a window management system that is consistent with the current X-Windows standards. In addition, it is desirable to provide a windows management system that allows users to combine window attributes including an always-visible attribute and a transparent background attribute.

SUMMARY OF THE INVENTION

A method and apparatus for establishing an always-visible class of windows in a computer-implemented windowing environment is provided. A user may designate one or more windows as always-visible windows. If an always-visible window overlaps with a non-always-visible window, then the always-visible window is displayed on top of the non-always-visible window. Always-visible windows are prevented from overlapping with each other. Techniques are provided for implementing the always-visible window class in a manner that complies with the X Windows system. According to one technique, the override redirect attribute is used as a flag to designate which windows are always-visible windows. According to an alternative technique, a list of always-visible windows is maintained as a property attached to a root window.

According to one aspect of the invention, a method for displaying information on a display device of a computer system is provided. According to the method, information is simultaneously displayed in a plurality of windows on the

display device. The plurality of windows includes a first always-visible window. A plurality of configurations that correspond to the plurality of windows is maintained. Specifically, the configuration for each window is maintained to reflect the location and dimensions of the window on the display device.

An event that causes a portion of a second window to occupy a common region on the display device with a portion of the first always-visible window is detected. Upon detecting such an event, it is determined whether the second window is also an always-visible window. If the second window is an always-visible window, then the configuration of one or both of the windows is altered to prevent overlap between the windows. If the second window is not an always-visible window, then the first window is displayed over the second window.

According to another aspect of the invention, a stack order is maintained for the plurality of windows. User input is received which causes the second window to have a higher position in the stack order than the first always-visible window. If the second window is not an always-visible window, then the stack order is altered to cause the first always-visible window to have a higher position in the stack order than the second window.

Various techniques may be used to designate a window as an always-visible window. According to one embodiment, the override-redirect attribute provided in the X-windows system is used as a flag to designate always-visible windows. According to another embodiment, a property attached to the root window is defined as an always-visible window list. To designate a window as an always-visible window, an entry that identifies the window is added to the always-visible window list. Both of these techniques may be used without deviating from the X-Windows standard.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. 1 illustrates a computer system upon which the preferred embodiment of the present invention can be implemented;

FIG. 2 illustrates a display device that is simultaneously displaying two always-visible windows and two normal windows on a screen according to an embodiment the invention;

FIG. 3 illustrates the screen of FIG. 2 after a user has selected a normal window that overlaps with an always-visible window;

FIG. 4 illustrates the screen of FIG. 2 when the user is in the process of selecting and enlarging a normal window to cause the normal window to overlap with an always-visible window;

FIG. 5 illustrates the screen of FIG. 2 when the resize operation illustrated in FIG. 4 has completed;

FIG. 6 illustrates the screen of FIG. 2 when a user has attempted to move an always-visible window into a new position that would cause the window to overlap with another always-visible window;

FIG. 7 illustrates the screen FIG. 2 after the operation shown in FIG. 6 showing how the window being moved is not allowed to overlap with another always-visible window;

FIG. 8 illustrates the screen of FIG. 2 when a user attempts to resize an always-visible window in such a way as to cause the always-visible to overlap with another always-visible window;

FIG. 9 illustrates the screen of FIG. 2 after the operation shown in FIG. 8;

FIG. 10 illustrates a functional block diagram of a system that implements always-visible windows according to an embodiment of the invention;

FIG. 11 illustrates a functional block diagram of a system that implements always-visible-windows according to an alternate embodiment of the invention;

FIG. 12*a* illustrates the operation of an X Client according to an embodiment of the invention;

FIG. 12*b* illustrates steps for designating an always-visible window according to one embodiment of the invention;

FIG. 12*c* illustrates steps for designating an always-visible window according to an alternative embodiment of the invention;

FIG. 13*a* illustrates the operation of a bump window manager according to an embodiment of the invention;

FIG. 13*b* illustrates the steps performed by the bump window manager to initialize an always-visible window list;

FIG. 13*c* illustrates the steps performed by the bump window manager to process the always-visible window list to avoid overlap between always-visible windows;

FIG. 13*d* illustrates the steps performed by the bump window manager in response to detection of an event which affects a window; and

FIG. 13*e* is a continuation of the flow chart illustrated in FIG. 13*d*.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A method and apparatus for simultaneously displaying multiple always-visible windows is described. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the present invention.

Referring to FIG. 1, the computer system upon which the preferred embodiment of the present invention can be implemented is shown as **100**. Computer system **100** comprises a bus or other communication means **101** for communicating information, and a processing means **102** coupled with bus **101** for processing information. System **100** further comprises a random access memory (RAM) or other dynamic storage device **104** (referred to as main memory), coupled to bus **101** for storing information and instructions to be executed by processor **102**. Main memory **104** also may be used for storing temporary variables or other intermediate information during execution of instructions by processor **102**. Computer system **100** also comprises a read only memory (ROM) and/or other static storage device **106** coupled to bus **101** for storing static information and instructions for processor **102**. Data storage device **107** is coupled to bus **101** for storing information and instructions.

Furthermore, a data storage device **107** such as a magnetic disk or optical disk and its corresponding disk drive can be coupled to computer system **100**. Computer system **100** can also be coupled via bus **101** to a display device **121**, such as

a cathode ray tube (CRT), for displaying information to a computer user. An alphanumeric input device **122**, including alphanumeric and other keys, is typically coupled to bus **101** for communicating information and command selections to processor **102**. Another type of user input device is cursor control **123**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **102** and for controlling cursor movement on display **121**. This input device typically has two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), which allows the device to specify positions in a plane.

Alternatively, other input devices such as a stylus or pen can be used to interact with the display. A displayed object on a computer screen can be selected by using a stylus or pen to touch the displayed object. The computer detects the selection by implementing a touch sensitive screen. Similarly, a light pen and a light sensitive screen can be used for selecting a displayed object. Such devices may thus detect selection position and the selection as a single operation instead of the "point and click," as in a system incorporating a mouse or trackball. Stylus and pen based input devices as well as touch and light sensitive screens are well known in the art. Such a system may also lack a keyboard such as **122** wherein all interface is provided via the stylus as a writing instrument (like a pen) and the written text is interpreted using optical character recognition (OCR) techniques.

The present invention is related to the use of computer system **100** as a platform to execute application programs that support the display of multiple always-visible windows. The preferred embodiment of the present invention has been designed for use with the X-Windows system. The X-Windows system was originally developed by MIT's Project Athena and Digital Equipment Corporation, and is now managed by the X Consortium. The X-Windows system is described in detail in *Xlib Reference Manual*, volumes 1 and 2, O'Reilly & Associates, Inc. (1995).

In the X-Windows system, functionality is distributed between client applications and a server application. The client and server applications may be executing on a single processor on a single workstation, or may be distributed among multiple processors on multiple workstations that are connected over a network.

Client Applications

The client applications transmit requests to the server application. The requests may include requests for the performance of a specified operation, or requests for information. The server application responds to the requests by performing the specified operation, or by sending a reply to the client application that includes the requested information.

Server Applications

In addition to servicing requests, the server application sends event messages and error messages to client applications. Event messages inform the client applications that some event has occurred. Typically, the client applications are designed to perform some action upon the receipt of certain event messages. Error messages notify the client that a previous request from the client was invalid.

The server application maintains complex abstractions of resources. Such resources may include, for example, windows, pixmaps, colormaps, cursors, fonts, and graphics contexts. The abstractions for a resource contain attributes for the resource. For example, the abstraction for a window includes information about the size, position, border width and stacking order of the window (the "configuration" of the window).

Because the abstractions are maintained with the server, only one copy of the abstractions is required, regardless of how many clients use the resources. Since clients do not have access to the abstractions themselves, the clients must transmit requests to the server application to manipulate or retrieve information about the resources. When a client transmits a request that relates to a resource, the client identifies the resource with an integer ID that corresponds to the resource. Since only an integer ID is sent rather than a complex abstraction, the traffic between the clients and the server is reduced.

The Window Manager

One special purpose client application is referred to as the window manager. The window manager is a client application that has certain special responsibilities. Specifically, the window manager mediates competing demands for the physical resources of a display, including screen space and the colormap. Typically, the window manager causes the server application to generate a user interface that allows a user to move windows about on the screen, resize windows, and start new applications.

When a client application requests a change in the configuration of a window, the client application sends a request to the server. However, since the request relates to a responsibility controlled by the window manager, the server application does not service the request. Instead, the server application cancels the request and transmits an event message that contains the arguments of the reconfiguration request to the window manager to inform the window manager of the reconfiguration request. The window manager then determines whether the modifications specified in the reconfiguration request should be performed, modified, or denied. If the window manager determines that the modifications should be performed, then the window manager sends the reconfiguration request to the server. Because the reconfiguration request is from the window manager, the server services the reconfiguration request. If the window manager determines that the reconfiguration request should be modified, then the window manager sends a modified reconfiguration request to the server application. The process of sending reconfiguration requests to the window manager for approval before the server acts upon the reconfiguration requests is referred to as substructure redirection.

Window Attributes

As mentioned above, the server application maintains complex data structures that contain information about resources. In addition to a window's configuration, the data structure for a window includes information about how the window is to look and act. This information is referred to as window attributes. One attribute of a window is referred to as Substructure Redirect Override. The Substructure Redirect Override attribute determines whether a window would be allowed to be mapped on the screen without intervention by the window manager.

Always Visible Windows

The present invention allows a client application to create and display windows that are always visible. Multiple always-visible windows may exist simultaneously without defeating the always-visible nature of the windows. The

always-visible windows may also exist simultaneously with any number of normal windows. In this context, normal windows refers to all windows that are not always-visible windows. The general behavior of always-visible windows shall now be described with reference to FIGS. **2–8**.

Window Behavior

According to the preferred embodiment of the invention, window behavior is governed by two simple rules. First, normal windows are never given higher positions in the stack order than always-visible windows. As a result, no portion of an always-visible window will ever be covered or obscured by a normal window. Second, always-visible windows are prevented from overlapping with each other. As a result, no portion of an always-visible window will ever be covered or obscured by any other always-visible window.

These rules are illustrated in FIGS. **2–9**. Referring to FIG. **2**, it illustrates a display device **200** that is simultaneously displaying two always-visible windows **204** and **206** and two normal windows **208** and **210** on a screen **202**. A visual indicator **212** is also shown on screen **202**. Visual indicator **212** is used by a user to indicate a location on screen **202**. Visual indicator **212** moves across screen **202** in response to user manipulation of a user input device, such as a mouse or trackball.

In the state of screen **202** illustrated in FIG. **2**, window **210** overlaps with and covers a portion of window **208**. Windows **204** and **206** overlap with and cover portions of window **210**. No portions of windows **204** or **206** are covered by any other windows.

As mentioned above, when two windows overlap, the determination of which window will cover the other hinges on the current position of the windows in the stack order. The window that is higher in the stack order is displayed in the overlapping region, thereby covering the windows that are lower in the stack order. Consequently, the state of screen **202** in FIG. **2** indicates that window **210** is currently higher in the stack order than window **208**, and that windows **204** and **206** are currently higher in the stack order than window **210**.

Numerous window manipulation operations may cause two windows to overlap. For example, a window may be moved from one location on screen **202** to another location on screen **202**. In addition, a window may be resized to cover a larger portion of screen **202**. Other window manipulation operations change the stack order. When the stack order is changed in such a way as to place a window that is covered by another window higher in the stack order than the window that is covering it, the window is redrawn to cover the other window. In typical windowing systems, a window must be selected before it can be manipulated. The selection process may involve, for example, operating a user input device to position visual indicator **212** over a visual portion of a window, and performing a predefined user input operation (such as clicking a mouse button). In typical windowing systems, the selection of a window automatically places the window at the top of the stack order. However, as shall now be described with reference to FIGS. **3** through **8**, the present invention modifies this standard windowing behavior to support always-visible windows.

FIG. **3** illustrates screen **202** after a user has selected window **210**. The borders of window **210** that are currently covered are illustrated with dashed lines. As mentioned above, in a typical windowing system, the selection of window **210** would cause window **210** to move to the highest position in the stack order. Therefore, window **219** would be redrawn to cover the portions of the other windows with which it overlaps. However, according to the present invention, a normal window such as window **210** is never moved to a higher position in the stack order than any currently existing always-visible window. Consequently, the selection of window **210** would not cause window **210** to move above windows **204** and **206** in the stack order. Therefore, after the selection of the window **210**, screen **202** would still appear as illustrated in FIG. **2**, with portions of windows **204** and **206** covering portions of window **210**. Thus, the selection of a normal window that overlaps with one or more always-visible windows does not cause the normal window to be moved higher in the stack order than the always-visible windows.

Referring to FIG. **4**, it illustrates a situation which a user has selected and enlarged window **208**. Normally, the selection of **208** would cause window **208** to move to the highest position in the stack order. However, based on the window behavior rules implemented in the present invention, window **208** is placed in the highest position in the stack order relative to other normal windows, but remains lower in the stack order relative to all existing always-visible windows. Consequently, after window **208** has been resized as illustrated in FIG. **4**, screen **202** would appear as illustrated in FIG. **5**. Specifically, window **208** would be placed higher in the stack order than window **210**, but still lower than windows **204** and **206**. Thus windows **204** and **206** would still cover window **208**, but window **208** would now cover window **210**. FIG. **6** illustrates an attempt to cause two always-visible windows to overlap. Specifically, FIG. **6** illustrates the situation in which a user has attempted to move window **206** into a new position on screen **202** that would cause window **206** to overlap with window **204**. As mentioned above, the present invention prevents two always-visible windows from overlapping. Consequently, rather than display window **206** in the position indicated by the user, the always-visible window that is being manipulated by the user is moved back to the closest non-overlapping previous position. The effect of this behavior is that two always-visible windows appear to bump into each other instead of overlapping. FIG. **7** illustrates the position of window **206** after the operation performed in FIG. **6**. Specifically, window **206** is now adjacent to but does not overlap with window **204**. It should be noted that the position of an always-visible window in the stack order is irrelevant with respect to other always-visible windows because always-visible windows are never allowed to overlap.

FIG. **8** illustrates an attempt to resize an always-visible window in such a way as to cause the always-visible window to overlap with another always-visible window. Specifically, window **206** has been resized to overlap window **204**. As in the previous example, the present invention responds by limiting the resize operation of window **206** to the closest non-overlapping previous position. This could result, for example, in the window positions illustrated in FIG. **9**.

It should be noted that moving the always-visible window operated on back to the closest non-overlapping previous position is simply one of many possible techniques for implementing the present invention. For example, overlaps between always-visible windows may also be prevented by returning the operated-on always-visible window to its initial state after any operations which would otherwise cause the always-visible window to overlap with another always-visible window.

Alternatively, overlap between always-visible windows may be prevented by allowing the movement of one always-

visible window to "push" other always-visible windows from their current positions. Thus, if a user attempted to move window **206** in FIG. **9** upward, window **204** would move upward along with it. Preferably, this upward repositioning of windows **204** and **206** would be halted as soon as window **204** reached the edge of screen **202**. The "push" technique of preventing overlap between always-visible windows requires window management routines that are more complex than are required by other overlap-prevention techniques. This complexity is due to the fact that the movement of one always-visible window may require the movement of any number of other always-visible windows (e.g. window A pushes window B which pushes windows C and D, etc.). The present invention is not limited to any specific manner of implementing the window behavior rules described above.

General System Description

FIG. **10** illustrates a functional block diagram of a computer system **1000** for implementing the window behavior described above. The computer system **1000** has a display device **1002**, an input device **1004**, and a window management system **1006**. The window management system **1006** manages the windows displayed on display device **1002**. In the illustrated example, three windows **1008**, **1010** and **1012** are currently displayed on display device **1002**.

The window management system **1006** generally includes a memory **1014**, a window display unit **1018** and an input reception unit **1020**. The memory **1014** contains a plurality of attributes **1022**, **1024** and **1026** of the windows displayed on display device **1002**. The attributes **1022**, **1024** and **1026** that are stored in memory **1014** indicate for each window a stack order position, a screen position, a size (including vertical and horizontal dimensions) and whether the window is an always-visible window.

An "always-visible" attribute is not one of the normal window attributes defined and supported in the X-Windows specification. Consequently, a system which includes a separately-defined always-visible attribute would constitute an extension to the X-Windows system, rendering the system incompatible with other systems. Therefore, the always-visible attribute does not exist as a separately-defined window attribute in the preferred embodiment. Rather, attributes and/or properties that pre-exist in the X-Windows system are used to store the value of the always-visible attribute. According to one embodiment, the "override-redirect" attribute, which is defined in the X-Windows specification, is used as an "always-visible" flag. In an alternative embodiment, a list is attached as a property of a root window and used to identify always-visible windows. These embodiments shall be described in greater detail below.

FIG. **10** illustrates the embodiment in which the override-redirect attribute is used as an always-visible window flag. In the illustrated example, attributes **1022** include data indicating that window **1008** is not an always-visible window, and that window **1008** is third in the stack order. Attributes **1024** include data indicating that window **1010** is not an always-visible window, and that window **1010** is second in the stack order. Attributes **1026** include data indicating that window **1012** is an always-visible window and that window **1012** is first in the stack order. The window display unit **1018** causes display device **1002** to display the windows **1008**, **1010** and **1012** based on the attributes **1022**, **1024** and **1026** stored in memory **1014**. If portions of two or more windows on display device **1002** share a common screen region, then the window display unit **1018** causes display device **1002** to display in the common screen region the portion of the window of the two or more windows that has a higher position in the stack order than the other windows. For example, windows **1008** and **1010** overlap. Because window **1010** is higher than window **1008** in the stack order, window **1010** is displayed in the overlap region.

The input reception unit **1020** is connected to the input device **1004** and receives input from a user. The input may be, for example, input that designates changes in the attributes stored in memory **1014**. Window display unit **1018** includes a plurality of units for processing the attribute changes. Specifically, window display unit **1018** includes an overlap processing unit **1028**, an overlap correction unit **1030**, a stack order processing unit **1032** and a stack order correction unit **1034**.

The overlap processing unit **1028** determines whether the changes cause two or more always-visible windows to overlap. The overlap correction unit **1030** alters the plurality of attributes **1022**, **1024** and **1026** as needed to prevent overlap between always-visible windows. The stack order processing unit **1032** determines whether the changes cause an always-visible window to have a lower position in the stack-order than any window that is not an always-visible window. The stack order correction unit **1034** alters the attributes **1022**, **1024** and **1026** as needed to prevent the always-visible window from having a lower position in the stack-order than any window that is not an always-visible window.

As described above, overlap processing unit **1028** and overlap correction unit **1030** cooperate to ensure that always-visible windows are never obscured by other always visible windows. Similarly, stack order processing unit **1032** and stack order correction unit **1034** cooperate to ensure that always-visible windows are never obscured by any window that is not an always-visible window. Consequently, always visible windows displayed on display device **1002** are never obscured by any other windows.

Client-based Implementation

As explained above, in the X-Windows system, window manager clients typically control the rules that govern user interface activity. All requests to affect the behavior or appearance of windows are first passed by the window manager through substructure redirection. Current window managers do not support the behavior of always-visible windows described above. Consequently, one embodiment of the present invention overrides substructure redirection for always-visible windows by setting the Substructure Override Redirect attribute of always-visible windows. Because the Substructure Override Redirect attribute is only set for always-visible windows, the value of the Substructure Override Redirect attribute also serves as a flag to distinguish always-visible windows from normal windows.

Once a client application that implements the present invention has identified the always-visible windows, as described above, the client maintains its own list of always-visible windows. The list contains information about each always-visible window, including the window ID, location and dimensions of the window.

The client then tracks all graphics events which may affect the visibility of the always-visible windows. If any graphic event would cause any portion of an always-visible window to become obscured, the client modifies the event to enforce the window behavior rules described above. Specifically, the client detects when a normal window is placed at the top of the stacking order and immediately transmits requests that

cause all always-visible windows to be placed higher in the stack order than the normal window. The client also detects when an always-visible window is moved or resized. The new position and size is compared with all other always-visible windows. If the window movement or size change causes the always-visible window to overlap with one or more other always-visible windows, then the client transits a request to reposition or resize the always-visible window to the closest non-overlapping position.

Window Manager-based Implementation

Rather than implement the present invention in a client application that circumvents the window manager to implement always-visible windows, the present invention may be implemented in a window manager. Similar to the client implementation, the window manager would maintain a list of the always-visible windows and counteract events that would cause any portion of an always-visible window to become covered or obscured. However, to prevent other clients from performing operations that would obscure a portion of an always-visible window, a flag other than the Substructure Override Redirect would be used to identify always-visible windows. For example, a list of always-visible windows (an "always-visible window list") may be defined and created as a property attached to the root window.

Referring to FIG. **11**, it illustrates an embodiment in which an always-visible window list **1102** is used to identify always-visible windows. The always-visible list **1102** includes a window identifier for each existing always-visible window. Specifically, always-visible window list **1102** includes an entry **1104** that corresponds to window **1012**, which is the only always-visible window on display device **1002**. During a resize window, select window or move window operation, window display unit **1018** accesses the always-visible windows list **1102** to determine whether particular windows are always-visible windows. Using an always-visible window list to identify always-visible windows allows joint control of always-visible windows by window display unit **1018** and a normal X system window manager.

X Client Application Operation

Referring to FIG. **12***a*, it is a flowchart illustrating the operation of an X Client application according to an embodiment of the invention. The X Client is designed to designate one or more windows as being "always visible". As discussed above, there are various possible methods for designating a window as an always-visible window. Reference to FIGS. **12***b* and **12***c* shall be made to describe two such methods. According to the first technique, all windows which have the "override redirect" attribute set are "always-visible" windows. According to the second technique, a list of window IDS for all always-visible windows is maintained in the form of a property attached to the root window. When this technique is used, each application which creates an always-visible window is responsible for adding the window ID to the always-visible window list at the time the window is created. A bump window manager, which will be described hereafter, removes the ID of an always-visible window from the always-visible window list automatically at the time that the always-visible window is destroyed.

Referring now to FIG. **12***a*, an X client connects to an X-Server at step **1202**. The X Client connects to the X-Server by making an Xlib call that establishes a communications path between the X Client and a designated X-Server.

At step **1204**, the X Client creates a window. At step **1208**, the X Client designates that the window created in step **1204** is an always-visible window. As explained above, the window may be designated as an always-visible window according to one of any number of techniques. One technique is illustrated in FIG. **12***b*. According to this technique, the Override-Redirect Attribute of the window is set at step **1216**.

An alternative technique for designating a window as an always-visible window is illustrated in FIG. **12***c*. According to the technique illustrated in FIG. **12***c*, the root window has a property which is defined as an always-visible windows list. At step **1218**, the always-visible windows list property is retrieved. At step **1220** a window ID that corresponds to the newly created window is added as an entry into the always-visible windows list. At step **1222**, the property of the root window that corresponds to the always-visible windows list is updated to reflect the revised always-visible windows list.

Referring again to FIG. **12***a*, the window is mapped at step **1210**. Mapping the window causes the window to be displayed on the appropriate display. At step **1212**, the client performs all client processing. This step generally represents the operation of the client. The steps actually performed during this step will vary based on the X Client and interaction between the X Client, the user, and other applications. During the X Client operation, various events may occur which affect the always-visible window. For example, other windows (both always-visible windows and non-always-visible windows) may be created, mapped, moved, resized and destroyed. When the X Client is through with all processing, the X Client destroys the window at step **1214**.

Bump Window Manger Operation

According to one embodiment of the invention, a bump window manager is used to create the window behavior described above. A bump window manager may be a component of an X Windows manager or may coexist-exist separately from an X Windows manager. The purpose of the bump window manager is to identify and monitor windows which have been designated as always-visible windows. If the stacking order is changed, the bump window manager ensures that all always-visible windows are stacked above all other windows. If an always-visible window is moved or resized, then the bump window manager will check for overlapping conditions with other always-visible windows. If such an overlap condition occurs, then the bump window manager will issue a move or resize operation to place the always-visible window on which the operation was performed at a previous position or size which does not overlap any other always-visible window. The operation of the bump window manager will be described in greater detail with respect to FIGS. **13***a*, **13***b*, **13***c*, **13***d* and **13***e*.

FIG. **13***a* is a flowchart illustrating the operation of a bump window manager. At step **1302**, the bump window manager connects to the X-Server. This establishes a communication path between the bump window manager and a specified X-Server.

At step **1304**, the bump window manager initializes an always-visible window list. Referring to FIG. **13***b*, it shows the steps performed by the bump window manager during step **1304** in greater detail. Specifically, at step **1314**, the bump window manager queries the X-Server for a list of windows. At step **1316**, the bump window manager identifies the always-visible windows in the list of windows and creates a list of the always-visible windows. Preferably, all always-visible windows are children of the root window.

The method used by the bump window manager to identify which of the windows identified by the X-Server are always-visible windows depends on the technique used to designate always-visible windows. For example, if the override-redirect attribute is used as a flag to designate always-visible windows, then the bump manager inspects the override-redirect attribute of all the windows identified by the X-Server. If a property attached to a root window is used to list the always-visible windows, then the bump window manager inspects the appropriate property of the root window.

At step **1318**, the bump window manager queries the X-Server for the size and position of all of the always-visible windows. At step **1320**, the bump window manager stores in an always-visible window list the sizes, positions, and window status of each of the always-visible windows. Consequently, the entry for each always-visible window in the always-visible window list includes the window ID, location, size, status (map/unmap) and stacking order of the always-visible window.

At step **1322**, the bump window manager processes the new list. The operations performed by bump window manager to process the new always-visible window list are illustrated in FIG. **13***c*. Referring to FIG. **13***c*, steps **1326**, **1338** and **1340** form a loop that is repeated until an overlap between mapped always-visible windows is encountered or until the entries for all of the always-visible windows have been processed. The information in an unmapped window cannot be obscured by another window because the information it is not even displayed. Therefore, in the preferred embodiment, overlap between an unmapped always-visible window and any other always-visible window is ignored.

When an overlap is encountered between a particular mapped always-visible window and one or more other mapped always-visible windows, then control passes from step **1326** to step **1328**. At step **1328**, the bump window manager determines a new position for the particular always-visible window which avoids overlap between the always-visible window and all other mapped always-visible windows. At step **1330**, it is determined whether such a position exists. If such a position exists, then the always-visible window is moved to the position at step **1336**. If such a position does not exist, then control passes to step **1332**.

At step **1332**, the bump window manager determines whether the size limit of the always-visible window has been reached. In this context, the size limit is the minimum size that the always-visible window is allowed to assume. If the size limit for the always-visible window has been reached, then control passes to step **1338** and the next always-visible window entry in the list is processed. If the size limit for the always-visible window has not been reached, then the size of the always-visible window is reduced. Steps **1326**, **1328**, **1330**, **1332** and **1334** form a loop such that the size of an always-visible window will be reduced until either the window can be moved to a non-overlapping position or its size limit has been reached.

Referring again to FIG. **13***a*, when the always-visible window list has been initialized, the bump window manager waits for a window event (step **1306**). When a window event occurs, control passes to step **1308** where the window event is window event occurs, control passes to step **1308** where the window event is processed. Step **1308** shall be described in greater detail with reference to FIGS. **13***d* and **13***e*.

Referring to FIG. **13***d* and **13***e*, they illustrate a flowchart of the steps performed by the bump window manager when a window event takes place. At step **1342** the bump window manager receives data that identifies the event that has occurred. At steps **1344** to **1358**, the bump window manager identifies the type of event which has occurred.

If the event specifies that a particular window is to be moved, then control passes from step **1344** to step **1360**. At step **1360**, the bump window manager determines whether the window on which the operation is to be performed is an always-visible window. If the window is not an always-visible window, then the bump window manager need not perform any further processing in response to the window event. If the window is an always-visible window, then control passes to step **1376**. At step **1376**, the bump window manager determines whether the move will cause the always-visible window to overlap with another always-visible window. If not, then the bump window manager need not perform any further processing in response to the window event. Otherwise, the always-visible window is moved to a non-overlap location in step **1384**. The non-overlap location may be, for example, adjacent to but not overlapping with the other always-visible window. At step **1390**, the entry in the always-visible window list that corresponds to the window that was moved is updated to reflect the new location of the window that was moved.

If the event specifies that a particular window is to be resized, then control passes from step **1346** to step **1362**. At step **1362**, the bump window manager determines whether the window on which the operation is to be performed is an always-visible window. If the window is not an always-visible window, then the bump window manager need not perform any further processing in response to the window event. If the window is an always-visible window, then control passes to step **1378**. At step **1378**, the bump window manager determines whether the resize operation will cause the always-visible window to overlap with another always-visible window. If not, then the bump window manager need not perform any further processing in response to the window event. Otherwise, the always-visible window is resized to a size in which the always-visible window does not overlap with any other always-visible window in step **1386**. The new size of the window will be smaller than the size specified in the resize event. For example, the size may be a size which causes the border of the resized window to be adjacent to but not overlapping with the border of the other always-visible window. At step **1392**, the entry in the always-visible window list that corresponds to the window that was resized is updated to reflect the new size of the window that was resized.

If the event specifies a change in the stacking order, then control passes from step **1348** to step **1364**. At step **1364**, the bump window manager determines whether any non-always-visible window is above any always-visible window in the new stacking order. If no non-always-visible window is above any always-visible window in the new stacking order, then the bump window manager need not perform any further processing in response to the window event. If any non-always-visible window is above any always-visible window in the new stacking order, then control passes to step **1380**. At step **1380**, the bump window manager adjusts the new stacking order to ensure that all always-visible windows are above all non-always-visible windows in the stacking order.

If the event specifies that a particular window is to be created, then control passes from step **1350** to step **1366**. At step **1366**, the bump window manager determines whether the newly created window is an always-visible window. If the window is not an always-visible window, then at step **1382** the bump window manager adjusts the stacking order

to ensure that all always-visible windows are above all non-always-visible windows in the stacking order. If the window is an always-visible window, then control passes to step **1388**. At step **1388** an entry is added to the always-visible window list for the newly created always-visible window.

If the event specifies that a particular window is to be destroyed, then control passes from step **1352** to step **1368**. At step **1368**, the bump window manager determines whether the window on which the operation is to be performed is an always-visible window. If the window is not an always-visible window, then the bump window manager need not perform any further processing in response to the window event. If the window is an always-visible window, then control passes to step **1396**. At step **1396**, the always-visible window list is updated. Specifically, the entry for the always-visible window that is to be destroyed is removed from the always-visible window list.

If the event specifies that a particular window is to be mapped, then control passes from step **1354** to step **1370**. At step **1370**, the bump window manager determines whether the window on which the operation is to be performed is an always-visible window. If the window is not an always-visible window, then the bump window manager need not perform any further processing in response to the window event. If the window is an always-visible window, then control passes to step **1398**. At step **1398**, the always-visible window list is updated. Specifically, the map/unmap status in the entry for the always-visible window is revised to reflect that the always-visible window is mapped. Once the entry has been revised, the always-visible window list is processed at step **1394** to ensure that no mapped always-visible windows overlap with any other mapped always-visible windows. The steps involved in processing the always-visible window list are described above with reference to FIG. **13***c*.

If the event specifies that a particular window is to be unmapped, then control passes from step **1356** to step **1372**. At step **1372**, the bump window manager determines whether the window on which the operation is to be performed is an always-visible window. If the window is not an always-visible window, then the bump window manager need not perform any further processing in response to the window event. If the window is an always-visible window, then control passes to step **1400**. At step **1400**, the always-visible window list is updated. Specifically, the map/unmap status in the entry for the always-visible window is revised to reflect that the always-visible window is no longer mapped.

If the event specifies that a property of a particular window is to be changed, then control passes from step **1358** to step **1374**. At step **1374**, the bump window manager determines whether the property to be changed is an always-visible window list. If the property to be changed is not an always-visible window list, then the bump window manager need not perform any further processing in response to the window event. If the property to be changed is an always-visible window list, then control passes to step **1402**. At step **1402** the always-visible window list is revised as specified in the event. Once the always-visible window list has been revised, the always-visible window list is processed at step **1404** to ensure that no mapped always-visible windows overlap with any other mapped always-visible windows. The steps involved in processing the always-visible window list are described above with reference to FIG. **13***c*.

Referring again to FIG. **13***a*, steps **1306**, **1308** and **1310** define a loop in which window events are processed as described above until a condition occurs which causes the bump window manager to terminate. Upon the occurrence of such a condition, control passes from step **1310** to step **1312**. At step **1312**, the bump window manager doses the connection that has been established between the bump window manager and the X-Server.

Transparent Backgrounds

According to another aspect of the invention, it is desirable to provide always-visible windows that have a transparent background. A transparent background allows a user to see the screen regions that are covered by the window. Only the foreground data within the window is not transparent. By providing always-visible windows with transparent backgrounds, one can ensure that certain data will always be visible and yet minimize the amount of information that is obscured by the always-visible window.

Possible Applications

The always-visible windows provided by the present invention are ideal for use in any computer application that requires the constant display of critical information. For example, in air traffic control certain data pertaining to aircraft must not be covered by any other information. Previously, this constraint did not allow air traffic control applications to take advantage of windows-based environments. However, by displaying the critical data in always-visible windows, air traffic control applications can take advantage of the convenience provided by windows-based graphical environments. Air traffic control is just one example of a field which would benefit significantly from the present invention. However, the present invention is not limited to any specific field of use.

While specific embodiments of the present invention have been described, various modifications and substitutions will become apparent by this disclosure. Such modifications and substitutions are within the scope of the present invention, and are intended to be covered by the following claims.

What is claimed is:

1. A method for displaying information on a display device of a computer system, the method comprising the steps of:

simultaneously displaying information in a plurality of windows on said display device, wherein said plurality of windows includes a first always-visible window;

maintaining a plurality of configurations that correspond to said plurality of windows, wherein the configuration for each of said plurality of windows reflects a location and dimensions of the window on the display device;

detecting an event that causes a portion of a second window of said plurality of windows to occupy a common region on said display device with a portion of said first always-visible window;

determining whether said second window is an always-visible window;

if said second window is an always-visible window, then altering either the configuration of the first always-visible window or the configuration of the second window, or the configurations of both said first always-visible window and second window, so that no portion of said second window occupies a common region on said display device with any portion of said first always-visible window.

2. The method of claim **1** further comprising the step of:

if said second window is not an always-visible window, then

displaying said portion of said first window in said common region.

3. The method of claim 1 wherein:

said first window has a transparent background;

said step of displaying said portion of said first window in said common region includes the steps of

displaying in said common region information from said first window, and

displaying in said common region information from a non-transparent window that overlaps with said first window.

4. The method of claim 1 further comprising the steps of:

maintaining a stack order for said plurality of windows, wherein each window of said plurality of windows has a position in said stack order;,

receiving user input to cause said second window to have a higher position in said stack order than said first always-visible window;

if said second window is not an always-visible window, then altering said stack order to cause said first always-visible window to have a higher position in said stack order than said second window.

5. The method of claim 1 wherein each of said plurality of windows includes an override-redirect attribute, wherein said step of determining whether said second window is an always visible window includes the step of determining whether the override-redirect attribute is set.

6. The method of claim 1 wherein:

said plurality of windows include a root window;

said root window has a property that is defined as an always-visible window list;

said always-visible window list includes an entry for each of said plurality of windows that is an always-visible window; and

said step of determining whether said second window is an always visible window includes inspecting said always-visible window list to determine whether said always-visible window list includes an entry for said second window.

7. The method of claim 6 further comprising the steps of:

detecting an event that destroys said first always-visible window; and

removing an entry that corresponds to said first always-visible window from said always-visible window list.

8. The method of claim 6 further comprising the steps of:

detecting an event that creates a new always-visible window;

the method further comprising adding an entry that corresponds to said new always-visible window to said always-visible window list;

determining whether said new always-visible window overlaps with any other always-visible window; and

if said new always-visible window overlaps with any other always-visible window, then altering either the configuration of the new always-visible window or the configuration of the other always-visible window, or the configurations of both said new always-visible window and the other always-visible window, so that no portion of said new always-visible window overlaps said other always-visible window.

9. A window management system for use on a computer system that has a display device, the window management system comprising:

a memory that contains a plurality of attributes of a plurality of windows, wherein said plurality of attributes indicate whether each window of said plurality of windows is an always-visible window, wherein said plurality of attributes indicate a stack order position for each window of said plurality of windows;

an input reception unit for receiving input from a user, said input designating changes in said plurality of attributes;

a window display unit for displaying said plurality of windows on said display device based on said plurality of attributes;

wherein if portions of two or more windows of said plurality of windows share a common screen region, then the window display unit displays in said common screen region the portion of the window of said two or more windows that has a higher position in said stack order than the other of said two or more windows;

wherein the window display unit includes

an overlap processing unit for determining whether said changes cause two or more always-visible windows to overlap; and

an overlap correction unit for altering said plurality of attributes to prevent overlap between said two or more always-visible windows;

a stack order processing unit for determining whether said changes cause an always-visible window to have a lower position in said stack-order than any window that is not an always-visible window; and

a stack order correction unit for altering said plurality of attributes to prevent said always-visible window from having a lower position in said stack-order than any window that is not an always-visible window.

10. The window management system of claim 9 further including a mechanism for maintaining a record of which of said plurality of windows are always-visible windows.

11. The window management system of claim 10 wherein:

said plurality of attributes include an override redirect attribute; and

said mechanism maintains said record by setting the override redirect attribute of each of said plurality of windows to reflect whether said window is an always-visible window.

12. The window management system of claim 10 wherein:

said plurality of windows include a root window;

said root window has a property defined as an always-visible window list;

said mechanism maintains said record by storing an entry into said always-visible window list for each of said plurality of windows that is an always-visible window.

13. A method for displaying important information in a window-based interface on a screen of a display device in a computer system, the method comprising the steps of:

displaying a plurality of windows on said screen, said plurality of windows including one or more always-visible windows;

displaying said important information in an always-visible window of said plurality of windows;

receiving user input that would cause a selected window of said plurality of windows to cover a portion of said always-visible window;

if said selected window is an always-visible window, then preventing said selected window from overlapping with said always-visible window; and

if said selected window is not an always-visible window, then displaying on said screen said always-visible window on top of said selected window.

14. The method of claim 13 further comprising the step of detecting when said user input would cause said selected window to overlap any of said one or more always-visible windows by performing the steps of:

storing orientation data that indicates a region of the screen that corresponds to each of said one or more always-visible windows;

detecting when an attempt is made to display said selected window in a new region on said screen; and

comparing the new region with the orientation data to determine if the new region intersects with the region of the screen that corresponds to any of said one or more always-visible windows.

15. The method of claim 13 further comprising the step of:

maintaining a stack order for said plurality of windows;

displaying said plurality of windows on said screen responsive to said stack order, wherein if any windows of said plurality of windows overlap, then the window with a higher position in said stack order is displayed above the windows with which it overlaps;

detecting when said user input would cause any window that is not an always-visible window to assume a higher position in a stack order than any of said one or more always-visible windows; and

causing said any window to assume a position in said stack order that is lower than all of said one or more always-visible windows.

16. The method of claim 13 further comprising the step of designating said always-visible window as an always-visible window by performing the step of setting an override-redirect attribute of said always-visible window.

17. The method of claim 13 further comprising the step of designating said always-visible window as an always-visible window by performing the steps of:

creating an always-visible window list; and

adding to said always-visible window list an entry that corresponds to said always-visible window.

18. The method of claim 17 wherein said step of creating an always-visible window list includes establishing said always-visible window list as a property of a root window.

19. The method of claim 17 wherein said entry includes a window identifier, a location indicator, a size indicator and a stacking order indicator for said always visible window.

20. The method of claim 19 wherein said entry further includes data that indicates whether said always visible window is mapped.

21. A computer-readable medium that has stored thereon sequences of instructions which, when executed by a processor, cause the processor to perform the method recited in claim 13.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,675,755

DATED : October 7, 1997

INVENTOR(S) : John Warren Trueblood

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 12 at line 34 delete "Manger" and insert -- Manager--.

Signed and Sealed this

Twelfth Day of October, 1999

Attest:

Q. TODD DICKINSON

Attesting Officer *Acting Commissioner of Patents and Trademarks*

US006847336B1

(12) **United States Patent**
Lemelson et al.

(10) **Patent No.: US 6,847,336 B1**
(45) **Date of Patent: *Jan. 25, 2005**

(54) **SELECTIVELY CONTROLLABLE HEADS-UP DISPLAY SYSTEM**

(76) Inventors: **Jerome H. Lemelson**, Suite 286, Unit 802, 930 Tahoe Blvd. Incline Village, NV (US) 89451; **John H. Hiett**, 1060 W. Boulder La., Flagstaff, AZ (US) 86001

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/720,662**

(22) Filed: **Oct. 2, 1996**

(51) **Int. Cl.**[7] **G09G 5/00**
(52) **U.S. Cl.** **345/8**
(58) **Field of Search** 345/7, 8, 9, 156, 345/157, 145, 146, 340, 348, 32; 351/210; 378/41, 42, 99

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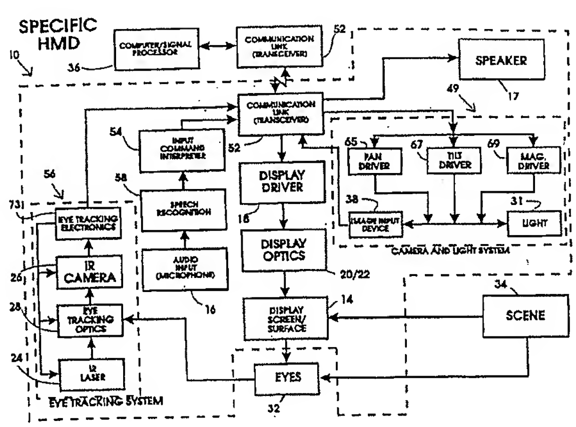
Primary Examiner—Chanh Nguyen
(74) *Attorney, Agent, or Firm*—Edwin A. Suominen; Douglas W. Rudy

(57) **ABSTRACT**

Systems and methods are disclosed for displaying data on a head's-up display screen. Multiple forms of data can be selectively displayed on a semi-transparent screen mounted in the user's normal field of view. The screen can either be mounted on the user's head, or mounted on a moveable implement and positioned in front of the user. A user interface is displayed on the screen including a moveable cursor and a menu of computer control icons. An eye-tracking system is mounted proximate the user and is employed to control movement of the cursor. By moving and focusing his or her eyes on a specific icon, the user controls the cursor to move to select the icon. When an icon is selected, a command computer is controlled to acquire and display data on the screen. The data is typically superimposed over the user's normal field of view.

14 Claims, 13 Drawing Sheets



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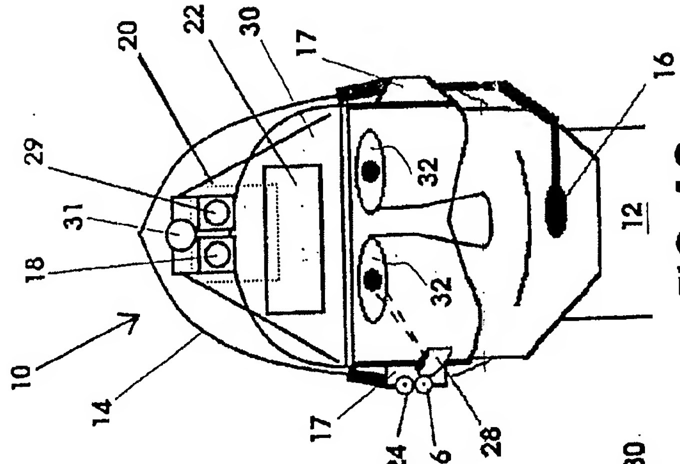


FIG. 1C

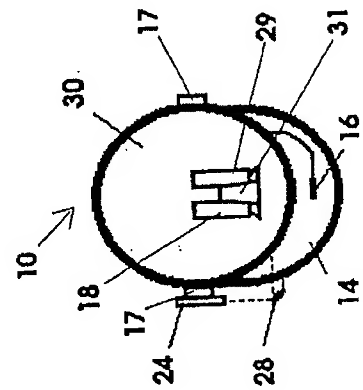


FIG. 1B

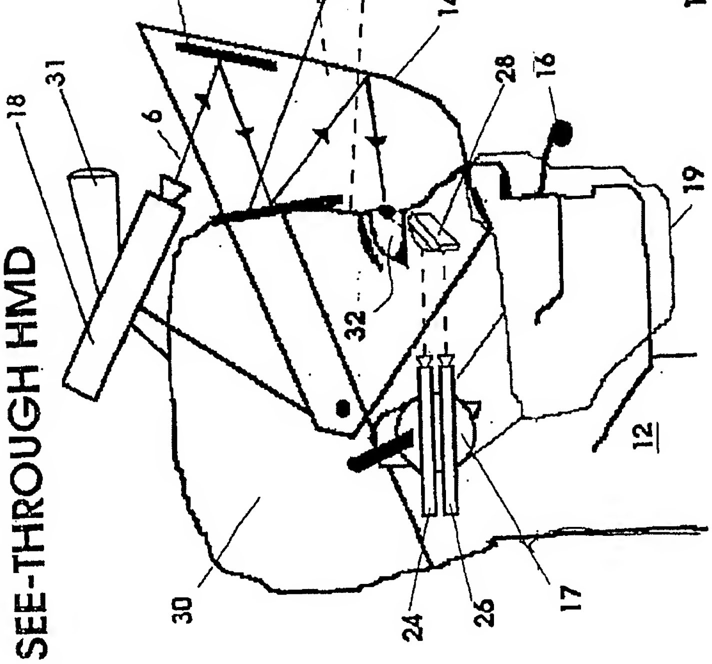


FIG. 1A

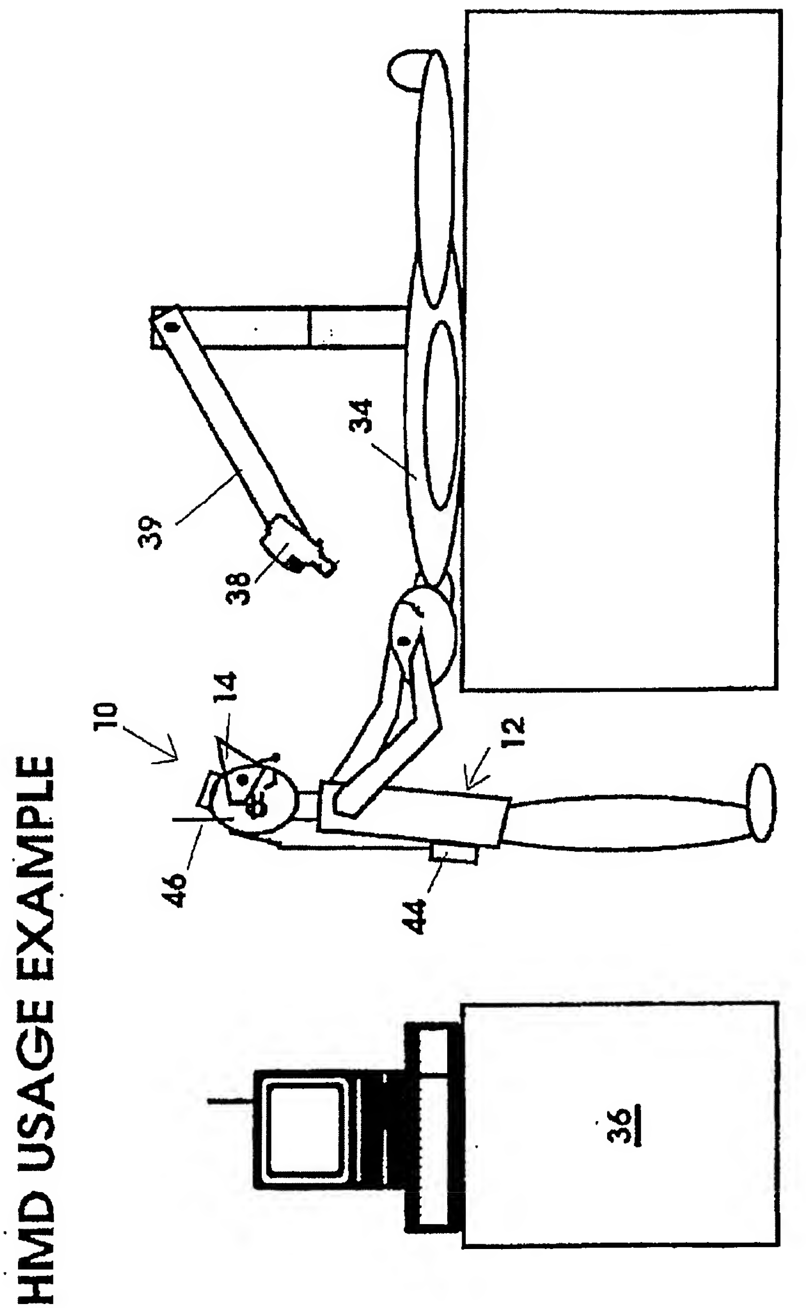


FIG. 2

GENERAL BLOCK DIAGRAM

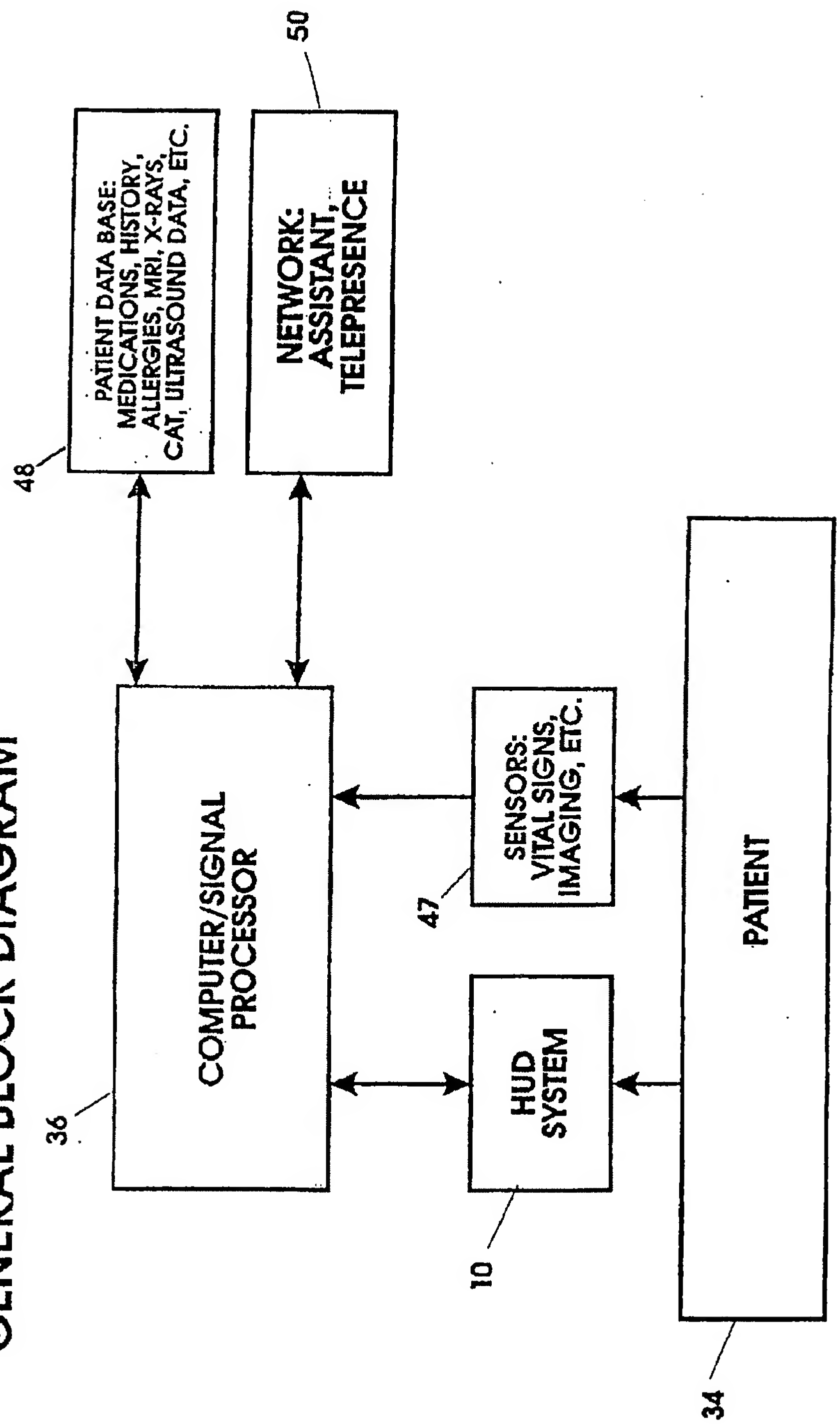
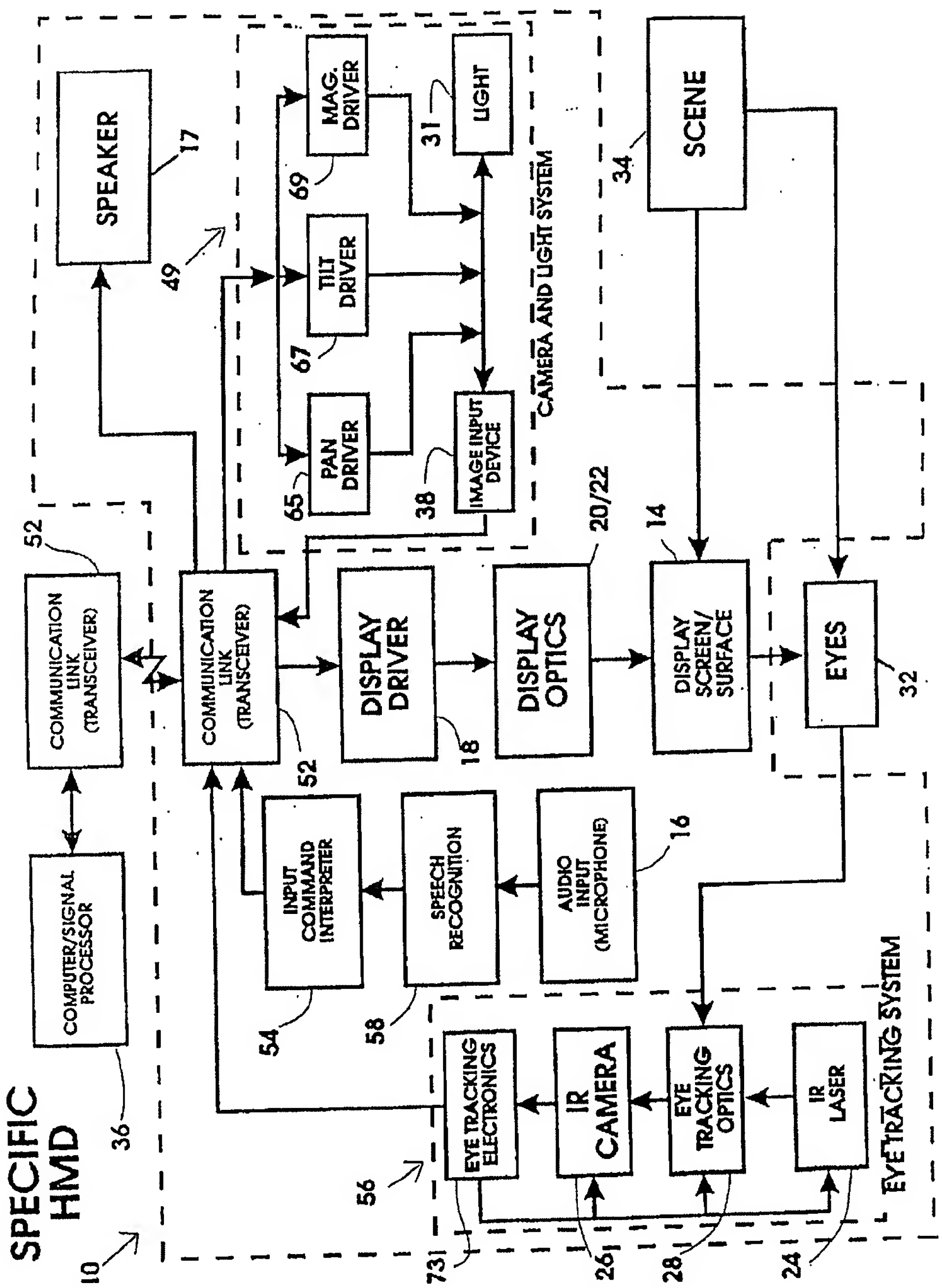


FIG. 3



SPECIFIC HMD
10
SPEAKER
17
49
MAG. DRIVER
69
TILT DRIVER
67
PAN DRIVER
65
LIGHT
31
IMAGE INPUT DEVICE
38
CAMERA AND LIGHT SYSTEM
SCENE
34
COMMUNICATION LINK (TRANSCEIVER)
52
COMPUTER/SIGNAL PROCESSOR
36
DISPLAY DRIVER
18
DISPLAY OPTICS
20/22
DISPLAY SCREEN/ SURFACE
14
EYES
32
INPUT COMMAND INTERPRETER
54
SPEECH RECOGNITION
58
AUDIO INPUT (MICROPHONE)
16
EYE TRACKING ELECTRONICS
IR CAMERA
EYE TRACKING OPTICS
IR LASER
EYE TRACKING SYSTEM
56
731
26
28
24

FIG 4

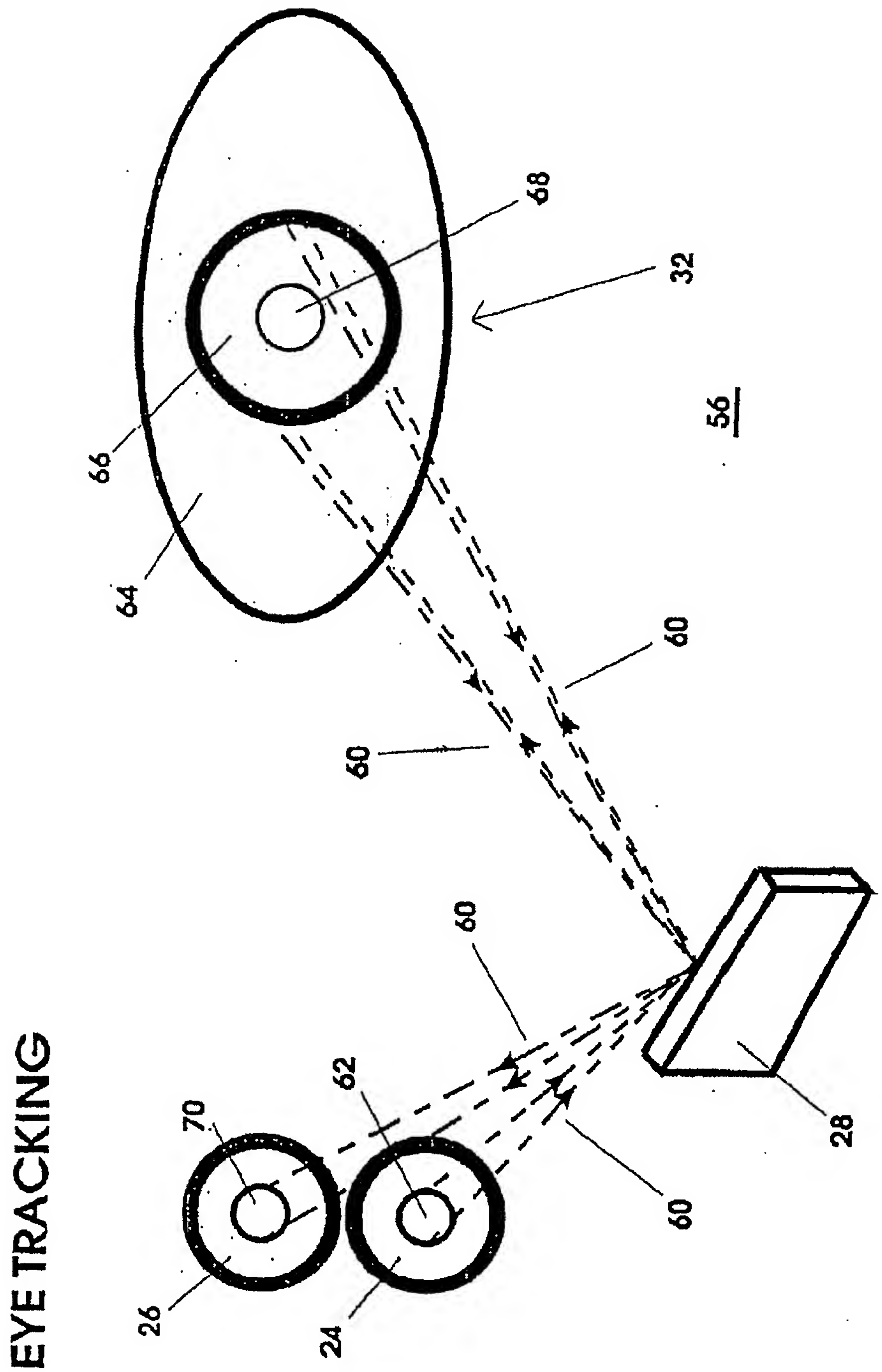


FIG. 5

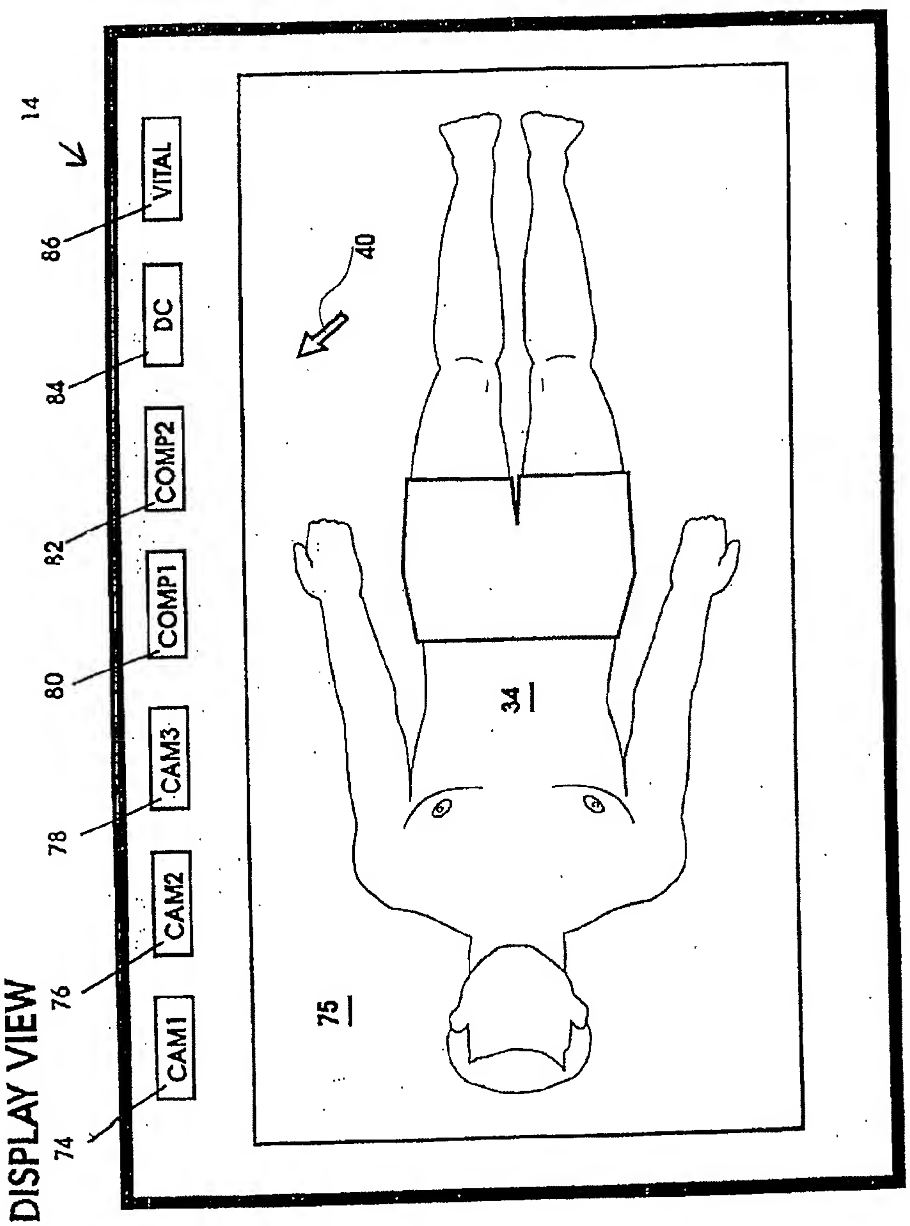

DISPLAY VIEW
14
CAM1
CAM2
CAM3
COMP1
COMP2
DC
VITAL
74
76
78
80
82
84
86
40
34
75
72

FIG. 6A

DISPLAY VIEW

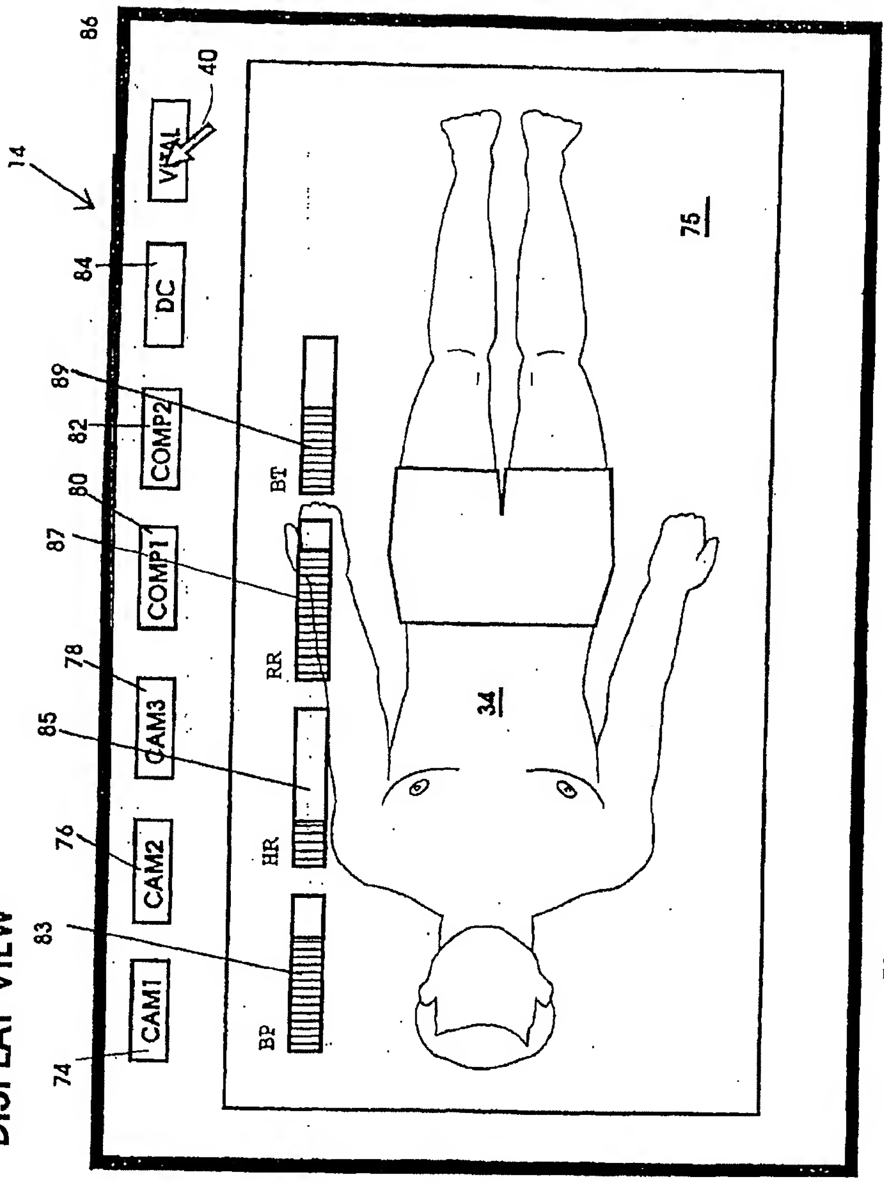


FIG. 6B

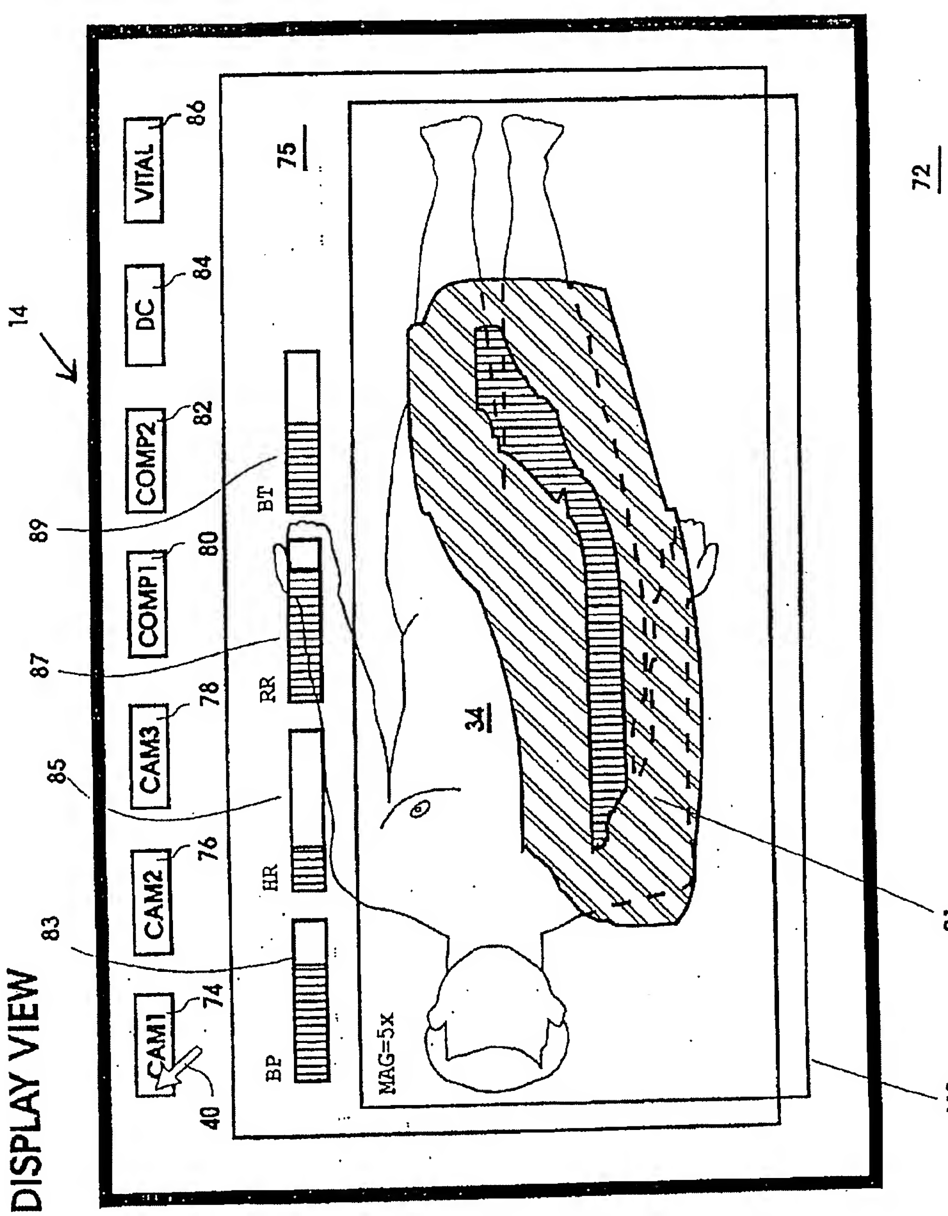
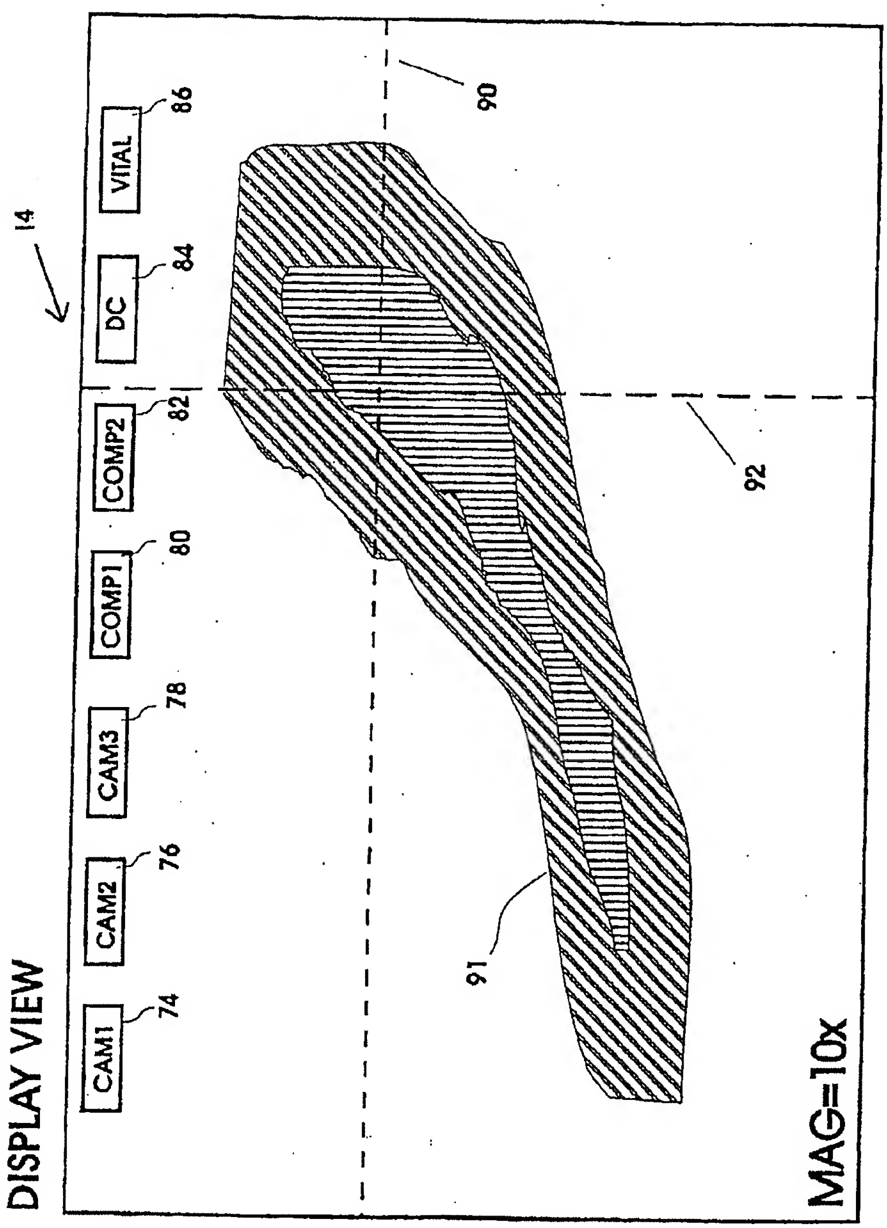

DISPLAY VIEW
14
CAM1
CAM2
CAM3
COMP1
COMP2
DC
VITAL
40
74
76
78
80
82
84
86
83
85
87
89
75
BP
HR
RR
BT
MAG=5x
34
91
110
72

FIG 6C


DISPLAY VIEW
14
CAM1
74
CAM2
76
CAM3
78
COMP1
80
COMP2
82
DC
84
VITAL
86
90
91
92
MAG=10x

72

FIG. 7A

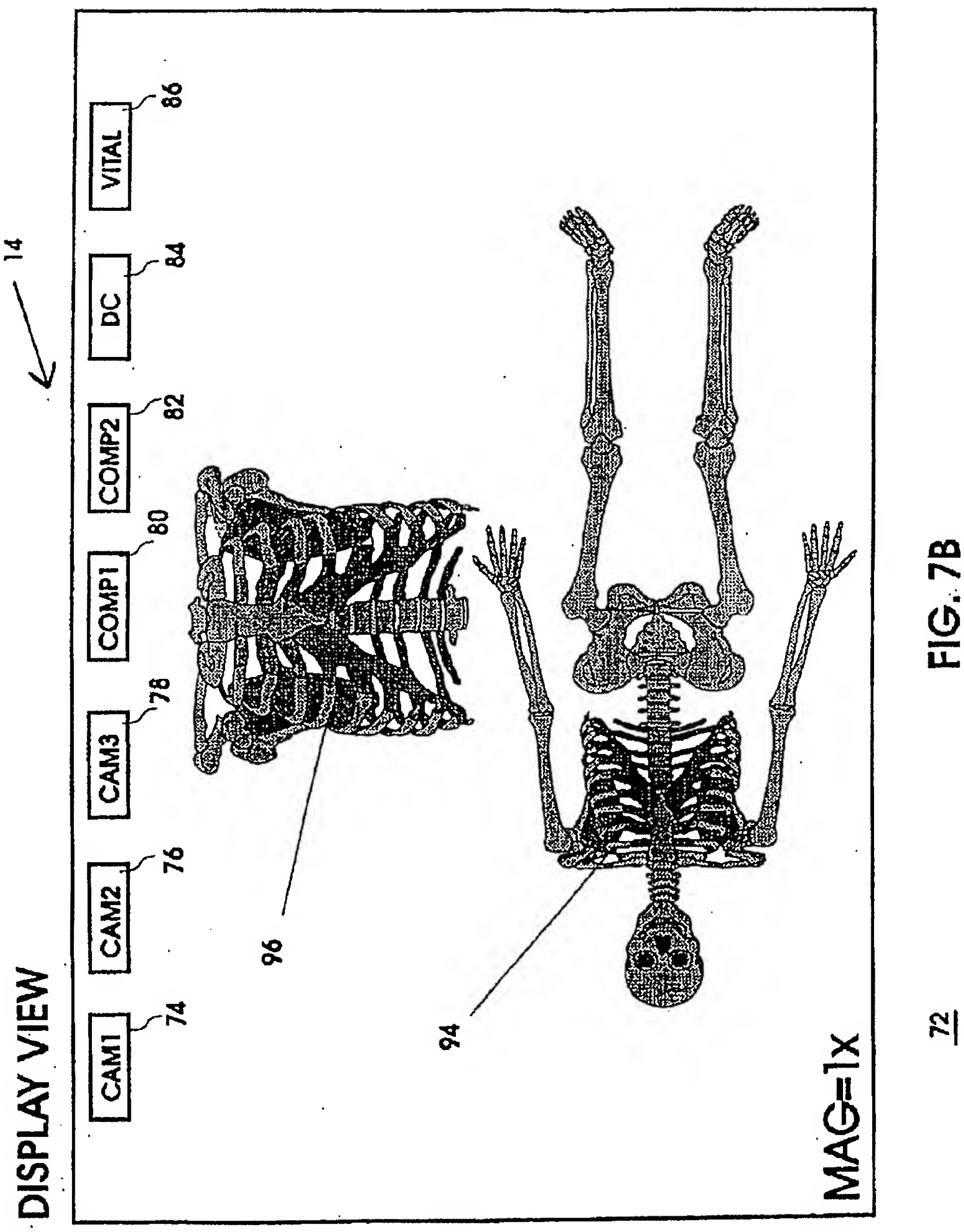

14
DISPLAY VIEW
CAM1
74
CAM2
76
CAM3
78
COMP1
80
COMP2
82
DC
84
VITAL
86
96
94
MAG=1X
72

FIG. 7B

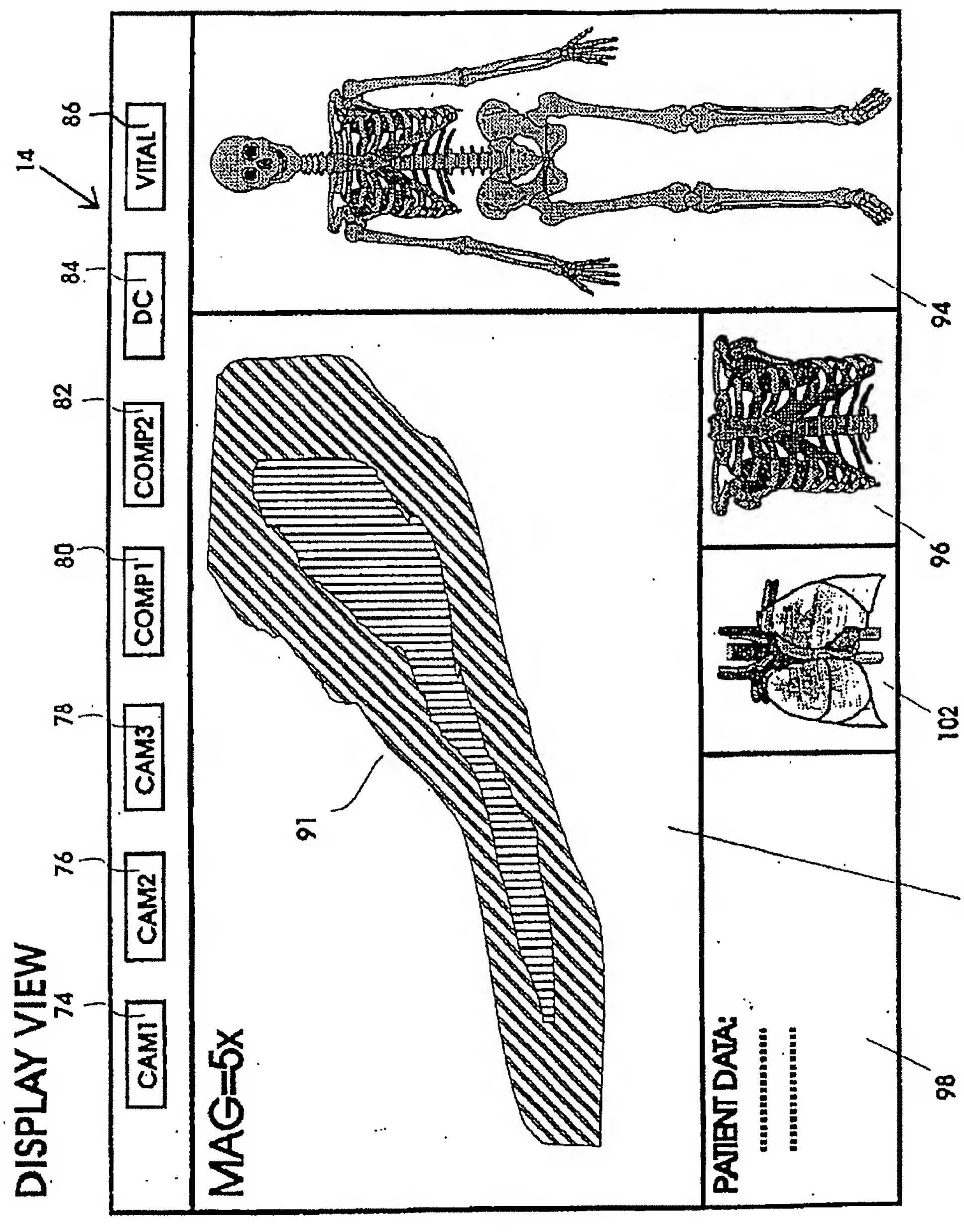

DISPLAY VIEW
14
CAM1
CAM2
CAM3
COMP1
COMP2
DC
VITAL
74
76
78
80
82
84
86
MAG=5x
91
PATIENT DATA:
94
96
98
100
102
72

FIG. 7C

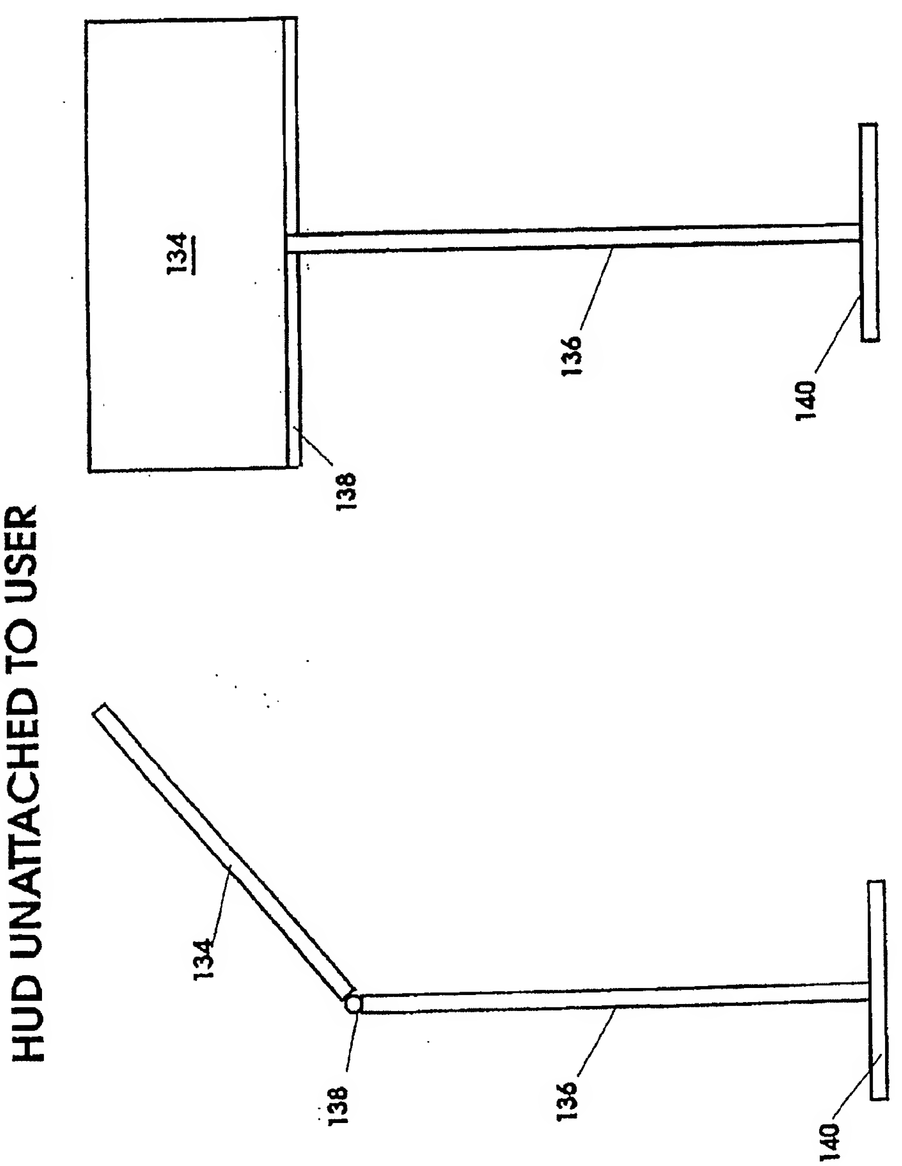


FIG. 8A

FIG. 8B

HUD UNATTACHED TO USER

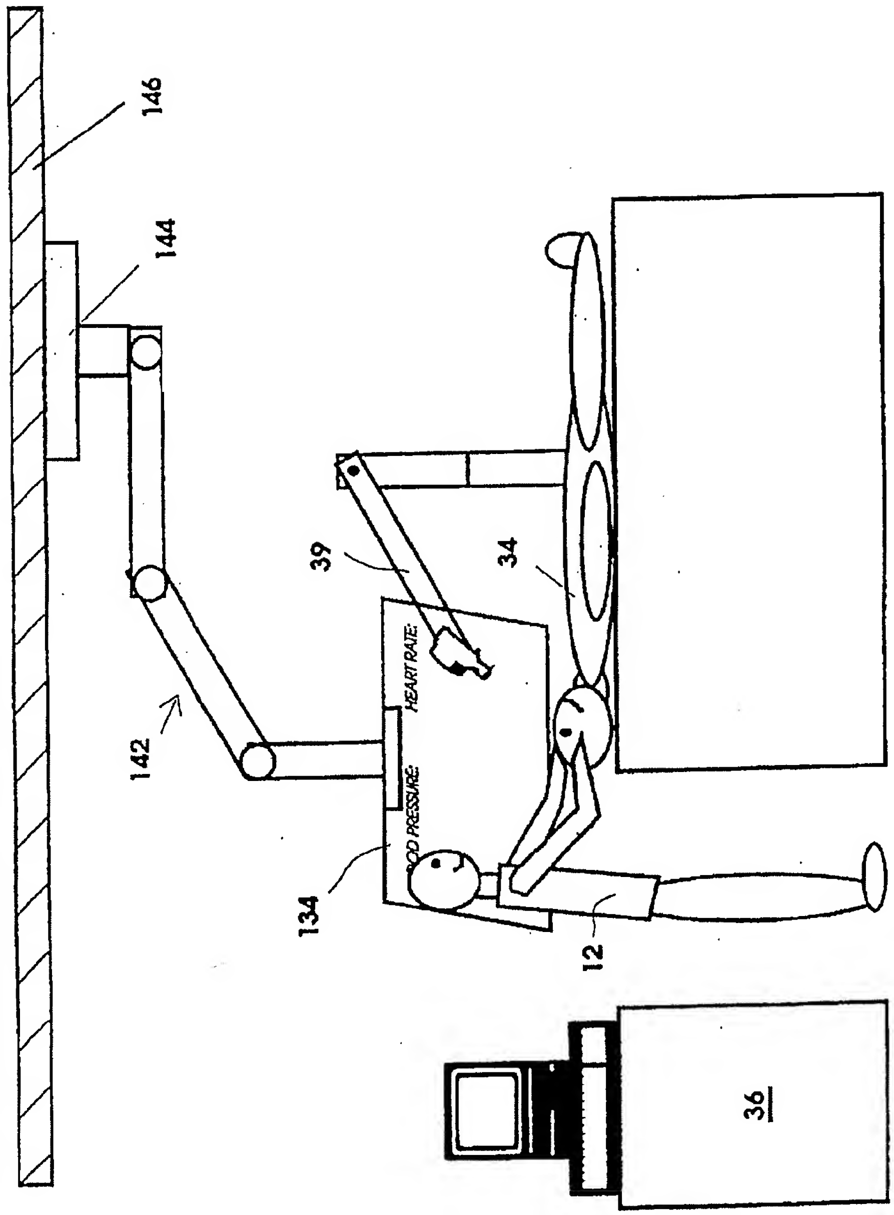


FIG. 8C

SELECTIVELY CONTROLLABLE HEADS-UP DISPLAY SYSTEM

FIELD OF THE INVENTION

The inventions relate to electronic display systems and control systems therefor. More particularly the inventions relate to selectively operable heads-up display systems for presenting information and/or image(s) to the user. In its preferred form, the heads-up display is configured for use by medical technicians or personnel, such as surgeons performing an operation.

BACKGROUND OF THE INVENTION

A heads-up display is generally defined as an electronically generated display containing information or data that is superimposed on an observer's normal field of view. As explained in greater detail below, heads-up display ("HUD") systems have been used in various applications. One such application is for use by pilots of aircraft. In the typical aircraft HUD system, a semi-transparent display screen is located generally in front of the eyes of the pilot (i.e. a screen mounted on the pilot's head or helmet, or in the view of the aircraft windshield). Such a system enables a pilot to concentrate on the difficult tasks associated with flying the aircraft, without diverting his attention to scan or examine a wide array of instruments.

It is also well known that medical technicians or personnel, such as surgeons, must keep track of many different types of information during an operation. For example, a surgeon must carefully view or monitor the physical surgery while simultaneously monitoring a patient's condition (e.g., blood pressure, heart rate, pulse, etc.). In addition, depending on the procedure, the surgeon must also monitor the status and settings of surgical equipment and tools. Although the additional information is necessary and important, monitoring such information often diverts the surgeon from the immediate task at hand.

Some surgical operations require that the surgeon divert his eyes to view a video monitor, for example, when performing highly complex laser or internal surgery conducted through scopes. See U.S. Pat. No. 5,222,477, which discloses an endoscope or borescope stereo viewing system. In addition, the surgeon may from time to time need to refer to data, such as defined by a patient's recorded or written history, or to previously taken x-rays or other computer generated images (e.g., CAT, NMR, 3D, etc.). For example, U.S. Pat. No. 5,452,416 discloses an automated system and a method for organizing, presenting, and manipulating medical images for viewing by physicians. See also U.S. Pat. Nos. 5,251,127 and 5,305,203, which disclose a computer-aided surgery apparatus that positions surgical tools during surgery or examinations. In each of the above-described systems, in order to view the displayed information, the surgeon must divert his or her eyes to a remote monitor.

Thus, surgeons use many different types of displays and must continually monitor many different sources of information. However, as more tools and sources of data become available to surgeons for use during operations, more opportunities for distraction arise. It is difficult for a surgeon to focus on his or her conduct during a surgical procedure while also continually shifting focus away from the patient to other monitors or indicators. Therefore, a need exists for conveniently, efficiently and accurately displaying to a surgeon various types and sources of information, views, and images of a patient undergoing a critical medical procedure.

As explained in greater detail below, prior attempts in the medical field to fulfill that need have been unsatisfactory.

For example, video signal sources have been adapted to scan views or images for different types of medical uses and applications. U.S. Pat. No. 4,737,972 to Schoolman ("Schoolman I") discloses a head-mounted device that provides stereoscopic x-ray images. Furthermore, U.S. Pat. No. 4,651,201 to Schoolman ("Schoolman II") discloses an endoscope that provides stereoscopic images of the patient on a display. Both Schoolman I and Schoolman II allows for the selective transmission of other video data to the display. However, Schoolman I and Schoolman II do not use a "see through" display that allows the surgeon to monitor both the environment around him and the video image. If the surgeon wishes to monitor or view the real-world environment, as opposed to the displayed graphics, the head-mounted display must be removed.

Efforts have also been made to use head-mounted displays in augmented reality simulations for medical applications wherein a desired image or three-dimensional model is superimposed on the real scene of a patient. For example, it was reported that a research effort in the Department of Computer Science at the University of North Carolina has attempted to develop a see-through head-mounted display that superimposed a computer-generated three-dimensional image of the internal features of a subject over the real-life view of the subject. Information describing those research efforts may be found on the World Wide Web in a document maintained by Jannick Rolland at the site on the World Wide Web Pages of the NSF/ARPA Science and Technology Center for Computer Graphics and Scientific Visualization at the University of North Carolina, Chapel Hill (http://www.cs.unc.edu/~rolland, cited February, 1996, copies of which are included in the information disclosure statement that has been filed concurrently with this application). That World Wide Web site in turn referenced the following publication: A. R. Kancheral, et al., "A Novel Virtual Reality Tool for Teaching 3D Anatomy," *Proc. CVR Med '95* (1995). Other research efforts at the University of North Carolina attempted to use a video see-through head-mounted display and a high-performance computer graphics engine to superimpose ultrasound images over the real view of the subject, thereby allowing a user to "see within" the subject. A set of trackers captured the motion of the body part with respect to the field of view of the user, and a computer updated the position of the body part in real time. The computer attempted to correlate the "tracked" position of the body with the three-dimensional model and to display the model on the heads-up display in a manner that gave the appearance of "x-ray vision."

In the above-described University of North Carolina research efforts, the focus was primarily to help teach students by superimposing a single computer-generated image over a moving, real-life, image of a subject. However, as explained in the associated literature, the "tracking" requirements made the research effort quite complicated, and the results appeared less than satisfactory. Moreover, such a teaching system is not applicable to the real-world environment of a surgeon, where the patient is not moved (and "tracking" is unnecessary), and where the surgeon needs or desires other information to be made readily available for viewing.

Still another research program associated with the University of North Carolina is described in Fuchs, et al., "Virtual Space Teleconferencing using a Sea of Cameras," *Proceedings of the First International Symposium on Medical Robotics and Computer Assisted Surgery* (Pittsburgh,

Pa., Sep. 22–24, 1994). That article describes research efforts that attempted to use a multitude of stationary cameras to acquire both photometric and depth data. The acquired data was purportedly used to construct a remote site in accordance with the head position and orientation of a local participant. According to the article, each participant wears a head-mounted display to look around a remote environment having surface geometries that are continuously sensed by a multitude of video cameras mounted along the walls and ceiling, from which cameras depth maps are extracted through cross-correlation stereo techniques. Views acquired from several cameras are then displayed on a head-mounted display with an integrated tracking system to provide images of the remote environment. The explained purpose of the effort was to duplicate, at a remote location, a three-dimensional virtual reality environment of a medical room. However, the article does not disclose the use of see-through displays providing a surgeon with the ability to select and display additional forms of data, or to superimpose data over a real-life view of the patient or surgical site.

Another type of head-mounted display is described in Yoshida, et al., "Optical Design and Analysis of a Head-Mounted Display with a High-Resolution Insert," *Proc. SPIE* 2537 (1995). That article describes yet another research program associated with the University of North Carolina in which a small area of a high-resolution image is inserted on a large field of a low resolution image displayed on a head-mounted screen. The system is described as using eye-tracking information to dynamically place the high resolution insert at the user's gaze point. The system purports to provide the user with both high-resolution imagery and a large field of view. In essence, using eye-tracking electronics, the "inserted image" corresponding to the user's gaze point is converted from low resolution to high-resolution. However, as above, the user can not select additional or alternative forms of data or different images to be superimposed over the primary image on the head-mounted display.

Thus, few head-mounted displays have been developed for the medical industry, and all those described above have had limited purpose and utility. On the other hand, and as discussed briefly above, a wide variety of head-mounted devices are commonly used in military applications. As mentioned, aircraft pilots, tank commanders, weapon operators and foot soldiers have all used head-mounted displays to display various forms of weapon or image information along with other data defining the real-world environment of the person wearing the display. For examples of such systems, see the following U.S. Pat. Nos. 4,028,725; 5,281,960; 5,000,544; 5,227,769; 4,994,794; 5,341,242; 4,878,046; 3,940,204; 3,923,370; 4,884,137; 4,915,487; and 4,575,722. Likewise, helmet or head-mounted displays have also been used for motorcycle riders. U.S. Pat. No. 4,988,976 discloses a motorcycle helmet that displays data or information such as speed, time, rpm's, fuel, oil, etc. on the transparent visor (i.e. vacuum fluorescent display) of the rider. Head-mounted displays that are worn in front of the user's eyes or worn as eye spectacles also exist. For example, see the following U.S. Pat. Nos. 5,129,716; 5,151,722; 5,003,300; 5,162,828; 5,331,333; 5,281,957; 5,334,991; 5,450,596 and 5,392,158.

The field of virtual reality also has driven advances in the use of various types of head-mounted displays. For example, see the following U.S. Pat. Nos. 4,636,866; 5,321,416; 5,347,400; 5,348,477; 5,406,415; 5,414,544; 5,416,876; 5,436,765; 5,479,224; 5,473,365; D363,279; 5,485,172; 5,483,307; 5,130,794. See also the publication *How Virtual Reality Works*, by J. Eddings (Ziff-Davis Press, Emeryville, Calif., 1994), and the site maintained by Rolland (referenced above) relating to telepresence systems and augmented reality.

Advances have also been made in the area of heads-up displays or screens that are not attached to or worn by the user. Most commonly, such systems are employed in automotive or military environments, to provide vehicle performance, weapon status, and other data for the driver or pilot. For examples of such systems, see the following U.S. Pat. Nos. 5,278,696; 4,652,870; 4,711,512; 4,729,634; 4,799,765; 4,927,234; 4,973,139; 4,988,976; 4,740,780; 4,787,711; 4,740,780; 4,831,366; 5,005,009; 5,037,182; 5,231,379; 4,824,228; 4,763,990; 4,669,810; 4,688,879; 4,818,048; 4,930,847; 4,932,731; 5,198,895; 5,210,624; 5,214,413; 5,302,964; 4,725,125; 4,188,090; 5,028,119 and 4,769,633.

Numerous advances have occurred in the specific forms of, and materials used in, heads-up display systems. See, for example, U.S. Pat. Nos. 4,987,410 and 4,961,625 (use of Liquid Crystal Displays (LCDs)); U.S. Pat. Nos. 5,108,479 and 5,066,525 (laminating glass plates or panels); and U.S. Pat. No. 5,457,356 (making a flat panel head-mounted display).

Also pertinent to this invention is the field of eye-tracking to control various computer or imaging functions. Various systems unrelated to the medical field have used eye-tracking for controlling a field of view. For example, see U.S. Pat. No. 4,028,725, which discloses an eye and head tracking system that controls a beam-splitter and retains the high-resolution part of the image in the field of view. The eye-tracking is carried out by infrared detection (i.e. see U.S. Pat. No. 3,724,932). See also U.S. Pat. Nos. 5,287,437; 4,439,755; 4,349,815; 4,437,113; 4,028,725 (referenced earlier) and the article "Optical Design and Analysis of a Head-Mounted Display with a High-Resolution Insert," referenced above, particularly at footnote 19, which refers to the Eye-tracking Systems Handbook, Applied Science Laboratories, Waltham, Mass. (1992).

Finally, video recording systems for recording scenery and heads up displays have been taught by the prior art. U.S. Pat. No. 5,241,391 to Dodds ("Dodds") discloses a video camera system that records scene conditions and heads-up displays.

Notwithstanding the large number of articles and patents issued in the area of heads-up or head-mounted displays, there has been no such display that is designed for the special needs of individuals performing detailed but critical tasks on relatively stationary subjects. Such a system would be extremely useful to personnel working in the fields of medicine, forensics, and micro-electronics.

Presently, there is a need for a selectively operable, head-mounted, see-through viewing display system for presenting desired information and/or images to a user, while at the same time allowing the user to view the real-world environment in which he or she operates. There is a further need to provide a convenient selectable viewing system that can be easily controlled by an eye-tracking cursor and speech recognition to control different images or displays on a video monitor or to control a field of view, while keeping the user's hands free to conduct precision operations.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an improved heads-up display system.

It is an other object of the invention to provide a "hands-free" heads-up display system that is useful to individuals

performing detailed procedures, such as those working in the fields of medicine, forensics, micro-electronics, biotech, etc.

It is another object of the invention to provide an improved head-mounted display that allows the user to view both the subject and selected data.

It is another object of the invention to provide an improved heads-up display that includes a user-friendly interface to a command control computer.

It is another object of this invention to provide an improved heads-up display that interfaces with a command control computer and includes an eye-tracking cursor to select menus to control computer performance and the display of data.

It is another object of this invention to provide an improved heads-up display that interfaces with a command control computer and includes a speech recognition circuit to control computer performance and display of data.

It is another object of the invention to provide an improved heads-up display that can be positioned between a surgeon and a patient in the surgeon's line of sight.

It is another object of the invention to provide an improved heads-up display that allows the user to view the subject while simultaneously monitoring the output from a number of different information sources, including imaging devices and remote or networked computer systems.

It is another object of the invention to provide an improved heads-up display that allows a medical technician to control medical imaging devices to obtain images of select parts of a patient and to display those images on the heads-up display.

It is another object of the invention to provide an improved heads-up display that allows a user to control a computer to acquire and display data defining a subject's history while simultaneously viewing the subject.

It is another object of the invention to provide an improved method for conducting surgery on a patient while simultaneously obtaining access to and conveniently displaying on a heads-up display a variety of types of data relating to the patient.

It is another object of the invention to provide an improved method of controlling a heads-up display by employing a "point-and-click" type user interface and cursor controlled by tracking movement of the eye.

It is another object of the invention to provide an improved method of controlling a heads-up display by employing speech recognition, both alone and in combination with an eye-tracking cursor.

It is another object of the invention to provide an improved heads-up display system that allows the user to control tools or instruments in a hands-free manner.

It is another object of the invention to provide an improved heads-up display system that allows a surgeon to control surgical tools or other instruments in a hands-free manner.

It is another object of the invention to provide an improved heads-up display maintained in an eyepiece of a scope or instrument and that is controlled with integral eye-tracking and speech recognition systems.

The above and other objects are achieved in an improved, selectively controllable system for presenting desired data on a head-mounted (or "heads-up") display. The system includes a command computer processor for receiving inputs that represent data and for controlling the display of desired data. The computer communicates with and controls the heads-up display system, which is configured to display the desired data in a manner that is aligned in the user's field of view. The heads-up display includes a user interface incorporating "hands-free" menu selection to allow the user to control the display of various types of data. In its preferred form, the hands-free menu selection is carried out using an eye-tracking cursor and a speech recognition computer to point to and select specific menus and operations.

The above and other objects are also achieved in an user-controllable heads-up system for presenting medical data to a physician. The system includes a command control computer for receiving inputs defining medical data and for controlling the display of that data on a head's-up display screen in the normal field of view of the physician. The heads-up display provides the physician with a "user interface" including menus and associated operations that can be selected with an eye-tracking cursor. The system also includes a microphone and speaker so that a physician can communicate with other personnel and computers both locally and remote from the site. The command computer includes a speech recognition processor to respond to spoken commands of the physician. The command computer also communicates with and receives a wide array of data from other computers networked therewith. The physician can select the specific data to be displayed on the screen. In addition, the physician can, with the eye-tracking cursor, control various medical imaging devices.

The above and other objects are also achieved in a method of selectively displaying multiple forms of data on a head-mounted display. In accordance with the method, a see-through computer display screen is mounted on a head piece that is worn by the user. A command computer controls a user interface so that command icons or menus are displayed in a super-imposed manner on the see-through, head-mounted display, thereby allowing the user to see both the normal field of view and the user interface. The user interface is provided with a "point-and-select" type of cursor. An eye-tracking system is integrated with the command control computer and the user interface to monitor the user's eye movement and to correspondingly control movement of the cursor. The user selects various computer operations from menus contained in the user interface by moving the eye-tracking cursor to selected menus or icons. By using the eye-tracking cursor to select various computer operations, the user can control the command computer to selectively display on the see-through HUD screen numerous items of data or images, while still seeing the normal field of view.

The preferred embodiments of the inventions are described below in the Figures and Detailed Description. Unless specifically noted, it is the intention of the inventors that the words and phrases in the specification and claims be given the ordinary and accustomed meaning to those of ordinary skill in the applicable art(s). If the inventors intend any other meaning, they will specifically state that they are applying a special meaning to a word or phrase.

Likewise, the use of the words "function" or "means" in the Detailed Description is not intended to indicate a desire to invoke the special provisions of 35 U.S.C. Section 112, ¶ 6 to define his invention. To the contrary, if the provisions of 35 U.S.C. Section 112, ¶6 are sought to be invoked to define the inventions, the claims will specifically state the phrases "means for" or "step for" and a function, without also reciting in such phrases any structure, material or act in support of the function. Even when the claims recite a "means for" or "step for" performing a function, if they also

recite any structure, material or acts in support of that means of step, then the intention is not to invoke the provisions of 35 U.S.C. Section 112, ¶ 6. Moreover, even if the inventors invoke the provisions of 35 U.S.C. Section 112, ¶ 6 to define the inventions, it is the intention that the inventions not be limited only to the specific structure, material or acts that are described in his preferred embodiments. Rather, if the claims specifically invoke the provisions of 35 U.S.C. Section 112, ¶ 6, it is nonetheless the intention to cover and include any and all structures, materials or acts that perform the claimed function, along with any and all known or later developed equivalent structures, materials or acts for performing the claimed function.

As a primary example, the preferred embodiment of this invention is configured for use by a surgeon performing an operation on a patient. However, the invention is equally applicable to any environment in which the user is conducting precision or detailed procedures with his or her hands on a relatively stationary subject, and where the user would find it advantageous to see data superimposed over the normal field of view. The potential applications are too numerous to mention, but would include forensics, microelectronics, biotechnology, chemistry, etc. Thus, even though the preferred embodiment refers to use by a surgeon, and to the acquisition and display of medical data, its applicability is much broader, and the claims should be interpreted accordingly.

Further, the description of the preferred embodiments make reference to standard medical imaging devices that are used to generate images to be displayed on the heads-up display. The disclosure specifically references several examples of such devices, including video cameras, x-ray devices, CAT and NMR scanners, etc. However, numerous other medical imaging systems are well known to exist, and most likely, numerous improved imaging devices will be developed in the future. Thus, the present invention does not depend on the type of imaging device that is implemented. The inventions described herein are not to be limited to the specific scanning or imaging devices disclosed in the preferred embodiments, but rather, are intended to be used with any and all applicable medical imaging devices. Likewise, the preferred embodiments depicted in the drawings show a single generic imaging device mounted on a manipulator arm. Numerous other tool and manipulator configurations, and multiple imaging devices, can be substituted for the single device.

Further, the specification in some places refers to several computers or controllers that perform various control operations. The specific form of computer is not important to the invention. In its preferred form, applicant divides several of the computing, control and analysis operations into several cooperating computers or embedded systems. However, with appropriate programming well known to those of ordinary skill in the art, the inventions can be implemented using a single, high power computer. Thus, it is not the intention to limit the inventions to any particular form or any number of computers, or to any specific computer network arrangement.

Likewise, the detailed description below shows at least two embodiments for the display screen. The preferred embodiment discloses the display screen mounted on the head of the user. The second embodiment shows the display screen positioned between the user and the subject, in a manner that is not mounted upon or supported by the head of the user. Additional embodiments also exist, and need not be disclosed. For example, the first embodiment can be modified for use in the eye-piece of a scope of any form, such as used in micro-electronics, biotech, medicine, forensics, chemical research, etc.

Similarly, the specific arrangement of the icons and menus that appear on the HUD screen, and the associated operations performed by those icons and menu items, are a matter of choice for the specific application. Thus, the invention is not intended to be limited to the specific arrangement and contents of the icons and menus shown and described in the preferred embodiments. For example, the icons and menu items for a selectively controllable heads-up display used by a dentist would likely be different than the arrangement used for a micro-electronics engineer.

Further examples exist throughout the disclosure, and it is not the intention to exclude from the scope of the invention the use of structures, materials or acts that are not expressly identified in the specification, but nonetheless are capable of performing a recited function.

BRIEF DESCRIPTION OF THE FIGURES

The inventions of this application are better understood in conjunction with the following Figures and Detailed Description of their preferred embodiments. The various hardware and software elements used to carry out the inventions are illustrated in the attached drawings in the form of block diagrams and flow charts. For simplicity and brevity, the Figures and Detailed Description do not address in detail features that are well known in the prior art, such as the literature listed in the Background of the Invention, above. However, to assure an adequate disclosure, the specification hereby expressly incorporates by reference each and every patent and other publication referenced above in the Background of the Invention.

FIGS. 1A, 1B and 1C depict side, top and front views, respectively, of a selectable heads-up display worn by a technician, such as a surgeon.

FIG. 2 shows an example for a basic configuration of an integrated head mounted display (HMD) and associated computer system used by a technician, such as a surgeon.

FIG. 3 is a block diagram of the primary components of the heads-up surgeon's display of FIG. 2.

FIG. 4 is a more detailed block diagram of a preferred embodiment of the heads-up display system.

FIG. 5 depicts an embodiment for the physical eye-tracking system implemented with an infrared laser.

FIG. 6A depicts an embodiment for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display on a transparent or see-through screen.

FIG. 6B depicts an embodiment for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display, with a patient's vital signs selected for display on a transparent or see-through screen.

FIG. 6C depicts an embodiment for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display, with a view from one of the cameras selected for display on a transparent or see-through screen.

FIG. 7A depicts an embodiment for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display, with a view from one of the cameras selected for display on a portion of the screen that has been made selectively non-transparent.

FIG. 7B depicts an embodiment for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display, with multiple x-ray images

from the computer or one of the cameras selected for display on a portion of the screen that has been made selectively non-transparent.

FIG. 7C depicts an embodiment for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display, with multiple forms of data and images displayed in windows on a portion of the screen.

FIG. 7D depicts another form for the display view and associated icons and menu items as seen by the surgeon wearing the heads-up display, with multiple forms of data and images displayed in various windows on a portion of the screen.

FIGS. 8A, 8B and 8C depict various views of an alternative embodiment implemented with a transparent heads-up display that is not worn by the surgeon, but rather, is movably stationed over the patient.

DETAILED DESCRIPTION

Shown in FIGS. 1A, 1B and 1C are three views of a head-mounted, selectable, display system 10. In the preferred embodiment shown in the Figures, the display system 10 is worn by a surgeon 12 performing an operation. However, the system is easily programmed for use by any individual performing detailed procedures in which it is advantageous to see the normal field of view, while also having access to and seeing in that field of view a variety of forms of data relating to the procedure. Thus, it is envisioned that a display in accordance with this invention will have many applications, but is primarily intended for procedures where detailed work is performed on relatively stationary objects. Accordingly, while the description below refers repeatedly to the user as a "surgeon", it should be understood that the other users are included in the scope of the invention.

For convenience, the phrases "head-mounted display," "heads-up display" and "HUD" are used interchangeably throughout this specification. The major components of the HUD system 10 as worn by the surgeon 12 include a display screen 14, microphone 16, speaker 17, display driver 18, camera 29, display mirrors 20 and 22, light 31, eye-tracking laser 24, eye-tracking detector 26, and eye-tracking optics 28. In its preferred form, each of these components are integrated into a single, adjustable head piece that is placed on the surgeon's head 30. Once placed on a surgeon's head 30, the various components are adjusted for proper operation. More specifically, the screen 14 is positioned comfortably in front of and in the normal line of sight of the surgeon's eyes 32, and the microphone 16 (placed in front of surgical mask 19) and speaker 17 are positioned so that the surgeon 12 can communicate with selected medical assistants and computers including an electronic speech recognition system, as discussed in greater detail below. The display driver 18 and display mirrors 20 and 22 are adjusted to superimpose selected images and data with light rays 4 from outside of HUD 10 on the display screen 14 via optical path 6. Likewise, the eye-tracking laser 24, eye-tracking detector 26, and eye-tracking optics 28 are aligned to detect and communicate eye movement to an eye-tracking computer, as also discussed below. In more compact versions of the head mounted display system discussed above and shown in FIGS. 1A, 1B, 1C, and 2, an eyeglass frame may be used to support the display surface 14, eye-tracking laser 24, eye-tracking detector 26, eye-tracking optics 28, or other components as desired.

Referring to FIG. 2, the surgeon 12 wears the HUD system 10 to simultaneously view selected data and images while performing an operation on a patient 34. In a preferred form, the surgeon 12 can selectively control the display screen 14 to operate between opaque or translucent modes. In the opaque mode, the screen 14 will display primarily the data or images generated from a control computer 36 or one or more video or medical imaging input device(s) 38, for example, when conducting particularly detailed or internal surgery. In the translucent mode, the surgeon 12 will be able to see through display screen 14 to the patient 34, while at the same time seeing the data or images generated by the computer 36 or imaging input device(s) 38.

To simplify the disclosure, only one imaging input device 38 is shown in FIG. 2. However, it is expressly noted that multiple numbers, and any and all forms, of image-generating systems can be employed in the proposed system. Thus, CCD, video, x-ray, NMR, CAT, and all other medical imaging systems can be employed. In its most basic form, the imaging input device 38 is mounted on a moveable and computer controllable manipulator assembly or arm 39, so that it can be controlled by the surgeon 12 through the HUD system to move to selected parts of the patient 34, and to obtain and magnify images of particular parts of the body, tissue or organs undergoing surgery. For a more detailed discussion on automatically controlled and moveable cameras, see U.S. Pat. No. 5,249,045 and the patents cited therein, all of which are incorporated herein by reference.

In operation, the surgeon 12 can command the HUD system 10, under control of computer 36, to selectively display on screen 14 various forms of data, graphics or images, including magnified or otherwise modified images from the imaging input device(s) 38, while at the same time looking through the screen 14 to view the patient 34 and the normal, real-life environment of the operating room. Thus, the surgeon 12 is able to directly view the patient 34, while at the same time, select from many forms of data for display on the HUD screen 14. For example, if the surgeon 12 is performing surgery in close proximity to critical organs, the surgeon may wish to see both the movements of his or her hands, and a superimposed magnified view from one of the image input device(s) 38. The surgeon 12 can control the video device 38 to move to and focus on the critical area or surgical site, and to obtain and magnify and image for display on the HUD display 14. In addition, the surgeon can control the computer system 36 to record the generated images, and then to display on the HUD screen 14 selected parts thereof after being magnified or otherwise computer enhanced. In accordance with the invention, the surgeon 12 has the great advantage of being able to simultaneously control the HUD and data acquisition systems, while also looking through the HUD display 14 to watch minute hand movements and other aspects of the local environment.

As explained in greater detail below, the surgeon 12 may command the computer 36 in several ways. In the preferred mode, the HUD system 10 incorporates eye-tracking to control a cursor that is displayed on the HUD screen 14. More specifically, as shown graphically in FIGS. 6A–6C, the standard display 14 includes menu items or icons that can be selected by a cursor 40 that is in turn controlled by an eye-tracking system. For example, when the surgeon 12 focuses his eyes on a selected icon or menu displayed on the HUD screen 14, the eye-tracking system will correspondingly cause the cursor 40 to move or "track" over the selected icon or menu item. The surgeon can then select the specific icon or menu by voice command or with a foot-operated select button (not shown) operating in a manner similar to the well known "mouse" button. Thus, the surgeon operates eye-tracking cursor 40 in a "hands-free" manner to

move onto icons and to select various imaging systems, computers or other data sources for display on the HUD display **14**.

Alternatively, or in combination with the eye-tracking cursor **40**, the HUD system **10** includes a standard speech recognition sub-system integrated with the command operations. Thus, the surgeon **12** can speak select speech commands or select words to select specific menus or to initiate computer operations to acquire and display select images or data. In the combined speech and eye-tracking mode, the surgeon can use his or her eye to move the cursor **40** to a particular menu or icon, and then speak commands to perform various operations associated specifically with that menu or icon, such as obtaining or magnifying images, selecting particular parts of patient histories, etc.

As shown in FIG. **2**, the HUD display system **10** preferably communicates with the command computer **36** via any appropriate form of wireless communication, as is well known in the art of computer networking. Thus, the surgeon is shown wearing a radio transmitter **44** and an antenna **46** that operate in a manner that is well known in the art to communicate with computer **36**. Although it is preferred to use wireless communication, it is expressly noted that any and all forms of wireless or wired communication can be used, and as a result, the invention is not intended to be limited to any specific form of data communication between the HUD system and the computer **36**.

As discussed above, the surgeon may use the HUD system as a hands-free interface to control an imaging input device **38** (shown as a camera in FIG. **2**) and its associated manipulator assembly **39** to obtain images of the patient **34**, and to display the images on the HUD display **14**. In addition, the surgeon can operate the HUD system as an interface to obtain from computer **36** (or from additional remote or local computers not shown) reference or other patient data, and to display that data on the HUD display **14**.

Shown in FIG. **3** is a general block diagram of the HUD system integrated in a surgeon's environment in accordance with the present invention. The HUD system **10**, including the referenced display, eye-tracking, speech recognition and communication elements, is coupled to a main command control computer **36**. Also coupled to the command computer **36** are the numerous sensor inputs **47**, such as those that monitor vital signs and acquire medical images. An electronic data base **48** of the patient's history is either coupled to or included in the memory of the command computer **36**. The command computer **36** has access over a standard network **50** to remote sites and computers (not shown).

There are numerous types of sensor inputs **47** that will monitor the patient **34** and generate data of interest to the surgeon **12**. Each such sensor **47** is considered old in the art, and operates to monitor and generate computer data defining the characteristics of the patient **34** in a manner well known to those of ordinary skill in the art. Thus, it is expressly noted that while several specific types of sensor inputs may be described in this specification, any and all types of sensor inputs **47** can be used, as long as the data is generated in a manner that is made accessible to the surgeon **12** by the command control computer **36**.

The patient data base **48** includes any and all type of patient data that a surgeon may wish to access, including, for example, the patient's history and prior medical images. While the data base **48** is shown in FIG. **3** as being separate from the command computer **36**, the data base can also be loaded into the data storage portion of the command computer **36**. Likewise, the patient data base **48** may be located remote from the command computer **36**, and can be accessed over the network **50**.

In its preferred form, the network **50** may access not only the standard hospital network, but also remote sites. In that manner, the surgeon **12** can access and communicate with other computers, expert systems or data devices (not shown) that are both local and remote from the surgeon's location. Likewise, specialists remote from the specific operating site may view the operation and communicate or consult directly with the surgeon **12**. More specifically, the remote sites can selectively display the operation from any number of cameras in the operating room, and in addition, can selectively display and view the procedure with the same perspective of the surgeon **12** through the HUD display screen **14**, using the head-mounted camera **29**. In that manner, specialists at the remote sites will see what the surgeon **12** sees, including the view of the patient **34** and the data, menus, icons and cursor shown on the HUD display screen **14**. In its preferred form, the video camera **29** is a remote controlled, high-performance camera that is mounted on the HUD gear worn by the surgeon **12** so that it can selectively view and transmit an image of the HUD screen **14** to the command computer **36**, and if desired, to a remote site or storage device (e.g., disk or video tape) controlled thereby. As shown in FIGS. **1B** and **1C**, the camera **29** can be mounted on the head of the surgeon **12** in a manner so as to make use of the same optics **20** and **22** used by the display driver **18**. In addition, as described below, the head mounted camera **29** and/or imaging device **38** may be mounted instead to the robotic arm **39** controllable by the surgeon to tilt, pan, zoom or otherwise focus upon, selected views of the patient. The head mounted camera **29** may also be mounted other than on the top of the surgeon's head. For example, the camera **29** can be mounted on the left side of the surgeon's head, wherein additional optics are used to scan the display screen **14**.

FIG. **4** shows a more specific diagram of the main components of the HUD display system **10**. The HUD system **10** is coupled to and communicates with the command control computer **36** via a communication link **52**. In its preferred form, the communications link comprises of two high speed digital radio transceivers or a optical communication system using fiber optic cable. The link allows for video, audio, and/or data to be transported to and from a computer network to and from the operator in the form of graphics, audio, video, text, or other data. For examples of such systems, see R. Gagliardi et al., *Optical Communications*, (John Wiley & Sons, Inc. NY, 1995), C. Lynch et al., *Packet Radio Networks: Architectures, Protocols, Technologies and Applications*, (Pergamon Press NY, 1987), J. Cabral et al., "Multimedia Systems for Telemedicine and Their Communications Requirements," *IEEE Communications Magazine* (July 1996), M. Tsiknakis et al., "Intelligent Image Management in a Distributed PACS and Telemedicine Environment," *IEEE Communications Magazine* (July 1996), and A. Hutchison, "Electronic Data Interchange for Health Care," *IEEE Communications Magazine* (July 1996). The above publications are incorporated herein by reference. It is noted that the communication link **52** can use any method of communicating appropriate signals or information to and from a computer system and/or network (i.e. including but not limited to a radio transceiver, fiber optic cable, wire etc.).

One use of the communication link **52** is to transmit to the command control computer **36** the input commands **54** generated by the surgeon **12**. The surgeon **12** generates the input commands **54** in one or more of several alternative

manners. Primarily, the commands **54** are generated when an eye-tracking system **56** detects the surgeon's eyes **32** focusing on selected icons or menu items displayed on the HUD screen **14**. The icons and menu items then cause the initiation of a corresponding operation, as is common with standard icon-based user interfaces employed with computers running the Macintosh or Windows 95 operating systems. Alternatively, the surgeon **12** may generate the commands orally by speaking select words or commands through microphone **16**. A standard voice recognition subsystem or computer **58** interprets the oral sounds output by the microphone **16**, and generates digital commands **54** in accordance with well known speech recognition processes. These speech commands **54** are then passed to command control computer **36** through communication links **52**. For more information on standard speech recognition systems, see C. Schmandt, *Voice Communication With Computers*, (Van Nostrand Reinhold, NY, 1994), and C. Baber et al., *Interactive Speech Technology: Human Factors Issues in the Application of Speech Input/Output to Computers*, (Taylor and Francis, PA, 1993), incorporated herein by reference. For more information on programming icon or menu based user interfaces, see J. Sullivan et al., *Intelligent User Interfaces*, (Addison-Wesley Publishing Company, NY, 1991), incorporated herein by reference.

The communication link **52** is also responsible for routing video images from a camera and lighting system **49** configured on the HUD system. More specifically, the camera and lighting system **49** generate video information under control of the surgeon **12** for display on the HUD screen **14**. Thus, using commands generated by speech or from the icon/menu system, the surgeon controls pan driver **65**, tilt driver **67**, magnification driver **69** and light **31** to focus upon selected scenes for imaging. The pan driver **65** controls pivotal movement in the horizontal direction by the camera while the tilt driver **67** controls the vertical pivotal scanning movement of the camera. The magnifier driver **69** controls the degree of zoom of the image input device **38**. The camera drivers each control a respective servomotor, stepper motor or actuator that moves or controls the associated camera parameter. In that manner, the surgeon can control the camera to focus upon and scan a particular feature (such as a tumor), and to generate and display on the HUD screen **14** highly magnified views thereof. In addition, the head mounted camera **29** can be controlled to scan the HUD screen **14** to generate, record and transmit to remote sites the view as seen by the surgeon **12**. Although only one head mounted camera **29** is actually shown in the drawings, it should be understood that multiple cameras can be used, including multiple different types of cameras (such as video, television, infra-red), and that those and additional cameras may be controlled by other than the surgeon **12**. Thus, the imaging input device **38** can either be controlled manually and/or automatically.

In addition to routing input commands **54**, eye vector information from eye-tracking system **56**, and data from image input device(s) **38** to the command control computer **36**, the communication links **52** also serve to route control information from the command computer **36** to the HUD system **10** to operate the various subsystems such as the speaker **17**, display driver **18**, display screen **14**, and imaging input device **38**. More specifically, the command computer **36** operates to maintain the contents of the display on HUD screen **14**, including maintaining the display of the basic menus and icons in accordance with the mode selected by the surgeon **12**, controlling and displaying movement of the cursor **40** (shown in FIGS. 6A, 6B, and 6C) in response to the eye-tracking system **56** and/or speech recognition system **58**, and displaying data and images obtained from the numerous available sources.

Thus, the command computer **36** regularly communicates, through communication links **52**, the control signals necessary to operate the display driver or generating system **18**, which in turn creates and projects the required elements of the basic user interface through the display optics **20**/**22** onto the HUD screen **14**. As the surgeon **12** moves his eyes **32** to focus upon the various icons and menus of the user interface, the eye-tracking system **56** generates input signals for the command computer **36**, which in turn controls the display generating system **18** to correspondingly move the cursor **40** (shown in FIGS. 6A, 6B, and 6C) on the display screen **14** in a manner that tracks the movement of the surgeon's eyes **32**. At the same time, the command computer **36** updates the status and contents of the various menus and icons, in a manner familiar to those who use a "point-and-click" user interface, such as found in common Windows '95 and Macintosh computer systems using a mouse, touch-pad or similar device. As various menus and icons are selected, further input signals **54** are generated for use by the command computer **36**, for example, to obtain patient data or past or current images. In response, the command control computer **36** carries out the required operations external to the HUD system **10** (such as controlling the sensor inputs **47** which may include imaging input device **38** or inputs from data base information **48** or other network **50** as shown in FIG. 3) to access and obtain the requested data. The command computer **36** then controls the HUD system **10** via communication links **52** to update the screen **14** to display for the surgeon the requested data or images, and to generate audio through speaker **17**.

The display driver or generating system **18**, shown in FIG. 4, operates to generate the images that are transmitted through the optics **20**/**22** and displayed on the HUD screen **14**. Such display drivers or systems are well known to those of ordinary skill in the art, and any applicable display system can be used. For example, it is known to use display generating devices such as CRTs, LEDs, laser diodes, LCDs, etc., and this invention is not limited to any particular system, as long as it can generate and display video or computer-generated images onto the display surface/screen **14** or directly into the user's eyes **32** thereby superimposing images over the surgeon's actual field of view. See, for example, the following references related to display systems, each of which are incorporated herein by reference: A. Yoshida et al., "Design and Applications of a High-Resolution Insert Head-Mounted-Display", *Proc. VRAIS' 95* (pgs. 84–93, 1995), E. Williams, *Liquid Crystals for Electronic Devices* (Noyes Data Corporation, NJ, 1975); M. Tidwell et al., "The Virtual Retinal Display—A Retinal Scanning Imaging System," *Proceedings of Virtual Reality World '95* (pgs. 325–334, Munich, Germany: IDG Conferences and Seminars, 1995); J. Kollin, "Optical Engineering Challenges of the Virtual Retinal Display," *Proceedings of the SPIE* (Vol. 2537, pgs. 48–60, Bellingham, Wash., 1995); J. Kollin, "A Retinal Display for Virtual-Environment Applications," *Proceedings of Society for Information Display* (1993 International Symposium, Digest of Technical Papers, Vol. XXIV, pg. 827, Playa del Rey, Calif.: Society for Information Display, 1993) and G. Robinson, "Display Prototype Uses Eye's Retina as Screen," *Electronic Engineering Times* (pgs. 33–34, Apr. 1, 1996).

In its preferred form, the HUD system **10** uses a projection method for displaying images in the user's field of view using a light source (e.g. CRT, LED, laser diode, LCD

projector, etc.). The light source intensity or brightness can be varied in the user's field of view so that the image being displayed can be more visible than the surrounding light. The light source intensity may also be decreased so that the surrounding light can become more visible and the image being displayed less visible.

Most CRT, LED, and other projection display methods require distance (optical path length) for projecting images. Thus, as shown in FIG. 1,.a CRT/LED projector 18 is used as the display driver. In order to make the display screen 14 as small as possible, display mirrors 20 and 22 are used to transmit the projected images to the screen 14. More specifically, mirrors 20 and 22 are located within the head-mounted system 10, and are positioned outside of the field of view of the user 12. However, they reflect the projected image so that it can be superimposed over a real scene on the display screen/surface 14 formed of a glass or other suitable display material. Another method of displaying images in the user's field of view is by using LCD technology embedded inside the display surface 14. Here light from the surrounding environment is blocked or filtered by the display when the appropriate voltage is applied to cells in a LCD matrix. Part of the control of the display screen 14 is done through eye-tracking system 56. This eye-tracking system 56 includes eye-tracking electronics 73, an infrared camera 26, eye-tracking optics 28, and an infrared laser 24, all of which are described below.

Shown in FIG. 5 is an example of an eye-tracking system 56. This system operates in a manner known to those of ordinary skill in the art. Several such systems are readily available, and the invention is not limited to any particular device, system, means, step or method for tracking the eye. For more detail on such eye-tracking systems, see for example the following U.S. Pat. Nos. 5,231,674; 5,270,748; 5,341,181; 5,430,505; 5,367,315; 5,345,281; 5,331,149 and 5,471,542 incorporated herein by reference. In its preferred form, a low power laser 24 generates an infrared eye-tracking laser beam 60. The laser beam is projected through a lens 62 and reflected by a mirror 28 onto the user's eye(s) 32. The user's eyes include a sclera 64, cornea 66, and pupil 68. When the user's eye(s) 32 move, the eye components cause distortions in the infrared laser beam, which are reflected back onto mirror 28, and then through a lens 70 into an infrared photodetector, infrared camera 26 or other type of photodetector. This distortion of the laser beam corresponds to the eye direction vector which can be measured accurately by eye-tracking electronics 73 (Shown in FIG. 4). Data defining the eye direction vector is subsequently transmitted from the eye-tracking electronics 73 to the command computer 36 through the communication links 52. For calibration, the eye-tracking optics which include mirror 28, lens 62, infrared camera 26, and laser 24, may be automatically adjusted for optimal performance through the use of computer controlled actuators (not shown).

It is expressly noted that, while separate eye-tracking electronics 73 are shown in the block diagram as carried by the heads-up display system 10, it is also possible to transmit the raw data from the infrared detector imaging device 26 to the command computer 36, which then determines the associated eye direction vectors. Likewise, the eye-tracking computer (and other electronics, if used) can be worn by the surgeon 12 on a belt or backpack (not shown).

Shown in FIGS. 6 and 7 are the contents and arrangement of several preferred forms of visual displays for the screen 14, including exemplary icons and menus for the user interface. Referring first to FIG. 6A, an object such a patient 34 is shown visible through the display 14 in the normal field of view 72 of the user 12. More specifically, a surgeon 12 wearing the HUD system 10 will see the patient 34 on table 75 through the semi-transparent display screen 14. The user will also see a number of icons or menu items 74, 76, 78, 80, 82, 84 and 86, superimposed over the real scene along the top portion of the normal field of view 72. Alternatively, the icons or menu items 74, 76, 78, 80, 82, 84, and 86 can be positioned along an opaque portion of the display screen 14, outside the normal field of view 72. The specific contents and form of the icon or menu items 74, 76, 78, 80, 82, 84, and 86, along with their associated computer operations, will vary depending on the specific implementation and programming. However, in its preferred form, there will be included icons or menu items that allow the user to control one or more cameras, access one or more computers, control the characteristics of the display 14, and display data, such as a patient's vital signs.

For example, as shown in FIG. 6A, three separate icons or menu items 74, 76 and 78, are assigned to control three cameras, indicated as CAM1, CAM2 and CAM3, respectively. By selecting any of these camera icons 74, 76, and 78, the user can independently control the associated camera systems to obtain (pan, tilt, rotate, zoom, etc.) and display various images. Similarly, two icons or menu items 80 and 82 are assigned to control access to two computers, indicated as COMP1 and COMP2, respectively. By selecting either of the computer icons, the user can access and control the associated computers or networks, to obtain patient data or other reference material. Another icon or menu item 84 is indicated with the label DC and is provided to allow the user to access and vary the characteristics of the screen 14. For example, the DC icon or menu item 84 can be accessed by the user to control brightness, contrast, and the degree to which you can see through the screen 14. Another icon 86 allows the user to control various devices to obtain and display on screen 14 any of a wide variety of vital signs.

As discussed above, each of the icons or menu items 74, 76, 78, 80, 82, 84, and 86 can be accessed and controlled by causing the eye-tracking cursor 40 to move over and select the desired icon. For example, referring to FIG. 6B, to see an update of the patient's vital signs, the surgeon can focus his or her eyes 32 on the icon 86 corresponding to the patient's vital signs. The eye-tracking system 56 will track the surgeon's eyes 32 to cause the cursor 40 to scroll to the VITAL icon 86. Depending on the programming of HUD system 10, when the cursor 40 tracks over the VITAL icon 86, the patient's vital signs will be superimposed over a portion of the surgeon's field of view 72. Shown in FIG. 6B is the display of the standard vital signs in analog graphic format. Specifically, graphics are shown for the patient's blood pressure 83, heart rate 85, respiratory rate 87 and body temperature 89. However, any additional vital sign (e.g., blood sugar, oxygen level, blood flow, etc.) can be programmed into the system and selected by the surgeon for display. In addition to, or in place of, the analog displays 83, 85, 87 and 89, digital values and titles can be displayed (not shown). Likewise, the system can be programmed to display the vital signs for a set period of time, continuously, or in an "on-off" fashion.

Referring now to FIG. 6C, there is shown the same view as FIG. 6B, with an image captured by an image input device 38 superimposed on the normal field of view 72. To select a camera and display its image, the surgeon 12 focuses his eyes upon the associated icon, for example, the CAM1 icon 74. As above, the eye-tracking system 56 causes the cursor 40 to track to icon 74, and correspondingly initiates the desired camera image to be superimposed over the image of

the patient 34. In the example shown in FIG. 6C, the image is a 5-times magnified image of an incision 91 in the patient. If desired, using appropriate menu icons, such as, for example, the display control icon 84, the surgeon may also cause the display screen 14 to operate in an opaque mode, displaying only the image of the incision 91 as if on a normal computer display screen. Likewise, the surgeon can magnify or otherwise control an image input device(s) 38 to obtain the image(s) desired, at the appropriate magnification. For example, FIG. 7A shows the display screen 14 operating in an opaque or semi-transparent mode with the incision 91 magnified to a 10-times view. Also shown in FIG. 7A, the cursor 40 has been replaced with a cross hair sighting system formed by dotted lines 90 and 92, thereby allowing the surgeon 12 to precisely select portions of the image to be still further magnified, enhanced, and/or centered in the display. By way of further example, reference is made to FIG. 7B, which depicts the display of skeletal FIGS. 94 and 96 selected as above by the surgeon 12 moving the cursor 40 to still another of the camera icons, for example, CAM2 icon 76.

If desired, the user interface and menu/icon programming can be configured to require the surgeon to take further action after the cursor 40 tracks over one of the icons. For example, and in the simplest form, once the surgeon causes the cursor to track over a selected icon, nothing may happen until the surgeon "clicks" a foot-operated mouse button (not shown). In more complex forms of the invention, the surgeon can actually access the selected operation by tracking the cursor to the selected icon and then speaking a select code word (e.g., "select" or "open") into microphone 16, which word or words are interpreted by speech recognition system 58. In still another form of the invention, the surgeon can access the selected operation associated with a particular icon or menu item by blinking a set number of times in quick succession after tracking the cursor 40 to the desired located. The blinking action is detected by the eye-tracking system 56.

In its simplest form, the selection by the surgeon of a specific icon will cause the associated data or images to be displayed on the screen 14. In such a mode of operation, it is desirable to include numerous icons on the periphery of the field of view 72, so that the surgeon 12 can quickly select an operation. In a more complex form of the invention, a series of menus can be associated with each icon, each menu having successively more detail. For example, instead of having three camera icons 74, 76 and 78, a single "video" icon can be substituted, which when selected by the cursor 40, will change the display to then show the individual icons for each of the many available cameras. Next, when one of the individual camera icons is selected by the cursor 40, the display will again change to show individual icons for the various camera controls, such to control the panning, tilting, rotating, magnification, filters, manipulator members, etc.

As indicated, in more complex forms of the invention, the HUD system 10 may incorporate a hierarchical icon or menu system, where several layers of menus are necessary to obtain and display desired data. In that case, greater flexibility is desirable in controlling how much data can be displayed on the screen 14 at any given time. More specifically, as shown in FIG. 7C, in the more complex forms of the invention, the well known programming techniques from the Macintosh or Windows 95 operating systems are adapted and included in command computer 36 to allow the display of multiple windows, that can be easily tiled, cascaded, selected, re-sized, or hidden in a manner now familiar to those skilled in the art. Thus, once a specific camera is selected, the surgeon 12 can simply "hide" the image until it is again desired to view it, at which point it can be easily selected. Thus, the surgeon is not required to sequence through each of the menu levels to access the desired image. For example, as shown in FIG. 7C, the user has configured and controlled the display to show the windows or regions having patient data 98, magnified camera view 100, MRI data 102, magnified skeletal view 96, and whole body skeletal view 94. The surgeon 12 can independently hide, re-size, and rearrange each of the windows, along with the transparency level of the screen 14, thereby providing a maximum of flexibility.

The flexibility of the system is further shown in FIG. 7D, which depicts the display 14 having various user selected information, data, or images positioned thereon at varying degrees of intensity or transparency. For example, in FIG. 7D the surgeon has placed in the center of the display 14 a semi-transparent window 108 through which the normal field of view 72 displays the patient 34. When the surgeon's eyes 32 are focused on the window 108, the cursor 40 switches to the eye-tracking cross hairs 90 and 92. Under control of the eye-tracking system 56, the cross hairs 90 and 92 allow the surgeon 12 to select a specific portion of the patient 34, such as incision 91. The selected portion (e.g., part of the incision 91) of patient 34 is then locked on and magnified as a separate view in a different window 112 in the manner described above where a different set of selectable cross hairs 115 and 117 are shown for further magnification. As also shown in FIG. 7D, data such as the patient name and procedure description is displayed in the title portion 114 at the top of the display screen/surface 14. The surgeon 12 has selected more detailed patient data 116 to be displayed in a separate window 116 in the lower left hand corner of display 14. Various medication listings 118 and recommendations 120, along with current cursor or cross-hair coordinates 122 are displayed in a top portion of screen 14. Also selected for display are programmable warning indicators 124, 126, and 128, generally shown at the top right portion of the display screen/surface 14. The warning indicators may be programmed by the surgeon 12 to monitor certain conditions and to visually indicate warnings at desired levels. The same programmable warning indicators will issue various levels of audible warning tones to the surgeon 12 through the speaker 17. In the configuration of FIG. 7D, the surgeon 12, has selected and displayed the vital signs in a separate window 130 at the top left corner of the display screen/surface 14, and a 3D model of a select portion of the patient in window 132, which is continually updated, is shown below the vital signs 130 and updated in real time. Other graphical information 110 is updated in real time and displayed at the bottom right corner of the display screen/surface 14. Other pertinent images or data may be selectively displayed in other areas of the display 14, for example skeletal images in area 131 and magnetic resonant imaging (MRI) data 132. All of the described operations can also be effected or initiated by using the speech recognition system 58.

Thus, the overall medical HUD system 10 is extremely flexible, allowing each surgeon to customize the display and use only the features deemed appropriate, necessary and desirable. In the simplest operating mode, the surgeon may choose to display on a small part of the screen 14 only the patient's vital signs, as shown in FIG. 6B. In other modes, and depending on the procedure, the surgeon may elect to proceed in a semi-transparent mode, with several windows of data or images, as shown in FIG. 7D.

Each of the variations in programming set forth above can be configured for each specific surgeon 12 in a computer file

assigned to that user and stored in command computer **36**. Thus, if a particular surgeon **12** prefers to have specific icons or menus shown on specific screens, or for example, prefers digital over analog displays for vital signs, that user can select those specific settings and the system will perform in accordance therewith. Similarly, the system allows for substantial customization for specific types of surgeons or fields outside of surgery (e.g., microelectronics, forensics, etc.).

Shown in FIGS. **8**A, **8**B, and **8**C is still another embodiment of the invention that incorporates a non-attached heads-up display screen **134**. In FIGS. **8**A and **8**B, the display screen/surface **134** is shown as a generally flat rectangular semi-transparent display area. The display screen/surface **134** is attached to a top end of a sturdy but flexible post **136** via joint **138**, thereby allowing it to be moved to various viewable positions. The joint **138** is also constructed to allow the screen **134** to be moved left or right relative to the post **136**. The lower end of post **136** is attached to a base **140** that is supported on the floor. The post **136** is also adjustable in height and can be bent to allow precise positioning of the screen/surface **134** by the user. In a further modification to this non-attached HUD embodiment, as shown in FIG. **8**C, the display screen **134** is mounted via robotic arm **142**. Display screen/surface 134 of HUD **10** is attached at a lower end of the multi-jointed, robotic arm or other manipulator **142**. The upper end of arm **142** is coupled to a mounting platform **144** that is fixed to the ceiling **146** of a room. Speech commands such as "Adjust Display On", "Adjust Display Off", "Up", "Down", "Left", "Right", "Forward", and "Backward" can be used for controlling the position of the retractable display screen/surface 134. Here the position of the display screen/surface **134** may be robotically controlled by speech signals from an operator **12**. Such speech signals may be received by a microphone and processed by a speech recognition system which thereby sends signals to a robotic microcontroller that drives the appropriate actuators to position the display screen/surface **134** as desired.

In the embodiments of FIGS. **8**A, **8**B and **8**C, the non-attached heads-up display system operates in a manner as described in the head-mounted HUD display embodiment of FIGS. **1–7**, thereby allowing the surgeon to select and display data in a superimposed manner over the normal field of view of the patient **34**. Both the speech recognition system **58** and eye-tracking system **56** can be used to move the cursor **40** to activate select icons or menus for operating computer **36** and display **134**. However, in the modified forms of the invention shown in FIGS. **8**A, **8**B and **8**C, additional methods for moving the cursor are possible, including using a low power laser mounted on head of the surgeon **12**, along with a touch screen incorporated in display screen itself.

The foregoing description of a preferred embodiment and best mode of the invention known to applicant at the time of filing the application has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and many modifications and variations are possible in the light of the above teaching. The embodiment was chosen and described in order to best explain the principles of the invention and its practical application, and to enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

For example, many computer-controlled instruments used in the micro-electronics field have one or more eyepieces through which the operator views a specimen. The preferred embodiment of the heads-up display can be easily modified for use in such applications. More specifically, because the user's eye is relatively aligned with the eye-piece, the eye-tracking laser can be unobtrusively mounted in or below the eye-piece shaft. The user interface can be displayed by a display driver onto the same view seen through the eye-piece. In the same manner as described for the preferred embodiment, the user can see the full realm of data in the normal field of view, while simultaneously controlling the associated computer. Still further modifications are possible without departing from the spirit and scope of the invention.

The HUD system's ability to provide high resolution images directly in the field of view of an operator without forcing the operator to look away can greatly enhance the ability to complete an operation in a very precise and controlled manner. This precise control can be incorporated into surgical cutting, probing, and/or positioning tools by clearly presenting the position of such tools onto the display with respect to a patient and/or patient model obtained from real time imagery. This technique can be very advantageous in the event that the actual orientation or position of such tool(s) is unobtainable from an unassisted eye but requires direct visual control to operate.

What is claimed is:

1. A heads-up display system for use by a medical technician, the heads-up display system selectively controllable by the medical technician comprising:

a) a transparent heads-up display screen including a plurality of icons including a vital signs icon, the transparent heads-up display screen worn on the head of the medical technician, the transparent heads-up display screen positioned in the normal field of view of the medical technician;

b) a command control computer coupled to the transparent heads-up display screen and including an electronic storage device;

c) a communication network coupled to the command control computer and further comprising:

i. a wide-area network for accessing medical data bases to be accessed by the medical technician and for communication and consulting with other medical technicians; and,

ii. signal transmitters and receivers for communication of information and images derived from the procedure for remote viewing, thus establishing a remote telepresence for consultation, education or other medical purposes;

d) an eye-tracking system integrated with the transparent heads-up display system, the eye-tracking system supported on the head of the medical technician and coupled to the command control computer and configured,

(i) to detect and track movement of one of the medical technician's eyes as the medical technician views the icons on the transparent heads-up display screen, and

(ii) to communicate to the command control computer eye-tracking data corresponding to the movement of the medical technician's eye to the icons on the transparent heads-up display; and

e) a user interface including:

(i) an icon control program stored in the electronic storage device and configured to cause the command control computer to generate and maintain on the display screen a plurality of selectable control icons, including a vital sign icon in a manner that is superimposed over the normal field of view;

(ii) a cursor control program stored in the electronic storage device and configured to cause the command control computer to: (1) generate and maintain on the display screen a moveable cursor in a manner that is superimposed over the normal field of view; (2) translate the eye-tracking data communicated from the eye-tracking system into cursor control data; (3) apply the cursor control data to cause the cursor displayed on the display screen to move in a manner that tracks movement of the medical technician's eye; and (4) generate process control data when the cursor is tracked over and selects the vital sign icon; and

(iii) a process control program stored in the electronic storage device and configured to cause the command computer to initiate specific control actions corresponding to the process control data generated when the eye-tracking cursor is moved to the vital sign icon.

2. The system of claim **1** wherein the heads-up display includes a display driver coupled to the command computer and configured so as to project images onto the display screen.

3. The system of claim **2** wherein the command computer is coupled to the heads-up display by a radio communication link.

4. The system of claim **3** wherein the command computer is coupled to the heads-up display by a wire communication link.

5. The system of claim **2** comprising a voice recognition system including:

a) a microphone placed proximate the user's mouth;

b) a speaker placed proximate at least one ear of the user;

c) a voice recognition circuit configured to recognize words spoken by the user and generate speech command signals corresponding thereto; and

d) wherein the process control program is configured to cause the command computer to initiate specific control actions corresponding to the speech command signals generated by the voice recognition circuit.

6. The system of claim **1** wherein the icon control program generates and maintains on the display screen the vital sign icon relating to data acquisition procedures.

7. A hands-free system for assisting medical practitioners in the performance of medical procedures on patients comprising:

a. a computer subsystem coupled to a patient medical data base subsystem, a communication network subsystem, a patient monitoring sensor subsystem, and a heads-up display (HUD) subsystem worn on the head of the medical practitioner;

b. the computer subsystem further comprising:

i. one or more computers programmed to respond to patient sensor inputs and to external HUD commands from medical practitioners; to retrieve and record medical data base information; to manage information flow to and from the external communication network; to transmit medical images and information to the HUD; and, to perform analysis of information and present results of the analysis;

ii. signal processing circuitry coupled to the computer subsystem for processing command signals and sensor information signals for input to the computer, and to process signals from the computer for audio, visual or other presentation to the medical practitioners;

iii. a first communication link for communicating with the heads-up display subsystem;

c. the heads-up display (HUD) subsystem further comprising:

i. a second communication link for communicating with the computer subsystem first communication link and with: (1) a HUD camera and light subsystem, (2) a HUD eye-tracking subsystem, (3) a HUD display subsystem, (4) a HUD audio input subsystem; and, (5) a HUD speaker subsystem;

ii. the HUD camera and light subsystem coupled to the second communication link;

iii. the HUD eye-tracking subsystem coupled to the second communication link;

iv. the HUD display subsystem coupled to the second communication link;

v. the HUD audio input subsystem coupled to the second communication link;

vi. the HUD speaker subsystem coupled to the second communication link;

d. the medical data base subsystem coupled to the computer subsystem and further comprising:

i. patient data base information including medical history, medical images, allergic reactions, family history and related data;

ii. treatment information for various maladies and recommended procedures;

iii. medication alternatives; and,

iv. surgical recommendations for different patient conditions;

e. the communication network subsystem coupled to the computer subsystem and further comprising:

i. a wide-area network for accessing medical data bases to be queried by the medical practitioner and for communication and consulting with other medical practitioners; and,

ii. signal transmitters and receivers for communication of information and images derived from the procedure for remote viewing, thus establishing a remote telepresence for consultation, education or other medical purposes;

f. the patient monitoring sensor subsystem coupled to the computer subsystem and further comprising:

i. vital sign sensors comprising blood pressure, heart rate, respiration rate, body temperature, or other patient status indicators;

ii. signal generators coupled to the vital sign sensors for generating coded signals representative of the measured vital signs; and

iii. communication circuitry coupled to the signal generators and the computer subsystem for formatting and transmitting sensor information to the computer sub-system;

g. the computer subsystem being further programmed to operate the HUD to provide a user selectable display options comprising:

i. patient images derived from the camera and lighting subsystem or from the computer data base information, including composite and overlay images,

ii. sensor icons displaying sensor measurements from the patient monitoring sensor subsystems;

iii. control icons or menus to control various subsystems including the camera and lighting subsystem panning, tilting, magnification or zooming and lighting; the display subsystem; and one or more computer subsystems;

iv. hierarchical icon or menu operation with layers of menus;

v. multiple simultaneously viewable display windows arranged in tiled format with selected images, patient information, text information, or other related information, the display windows being semitransparent or opaque under user or under program control, individual windows being further selectable for expanded viewing, resizing, hiding, or rearrangement,

vi. selectable, programmable warning indicators to visually indicate warnings at desired levels,

vii. the display options being user selectable and controllable using the HUD eye-tracking subsystem by tracking the medical practitioner's eyes causing an eye tracking cursor to move over the display with user selection of the desired icon or menu by specific eye movements, a spoken command, or foot actuation of a system control to direct desired operations and displays.

8. The invention in accordance with claim 7 wherein the first communication link of the computer subsystem further comprises:

a wireless radio for transmission and reception of signals;

an antenna coupled to the wireless radio; and

signal routing and control circuitry for routing various signals to and from the computer subsystem.

9. The invention in accordance with claim 8 wherein the second communication link of the HUD subsystem comprises:

wireless radio for transmission and reception of signals;

an antenna coupled to the wireless radio;

couplings to the HUD eye-tracking subsystem, display subsystem, audio input subsystem, camera and light subsystem and speaker subsystem for receipt and delivery of messages and signals to, from and between these HUD subsystems; and,

signal routing and control circuitry for routing various signals to and from respective subsystems.

10. The invention in accordance with claim 9 wherein the HUD camera and light subsystem coupled to the second communication link comprises:

at least one imaging device, such as a CCD camera, an x-ray scanner, a NMR scanner, a CAT scanner, a sonic scanner, or other medical imaging scanner, coupled to a pan driver, a tilt driver, a magnification or zoom driver and an illumination light for capturing images of selected areas of a subject patient for display, analysis or recording, the imaging device being further coupled to the second communication link for delivery of images of selected areas of the patient to the computer subsystem and to the HUD display subsystems;

the pan driver coupled to the second communication link to receive control signals and further coupled to the imaging device to enable controllable panning of the subject patient with the imaging device to view different areas of the patient;

the controllable tilt driver coupled to the second communication link to receive control signals and further coupled to the imaging device to enable varying the viewing angle of the selected patient area with the scanning device

the or zoom or magnification driver coupled to the second communication link to receive control signals and further coupled to the imaging device to enable controllable magnification of selected areas of a subject patient; and,

the light receiving control signals to provide controllable illumination to selected areas of a subject patient to enhance user or imaging device visibility.

11. The invention in accordance with claim 10 wherein the HD eye-tracking subsystem coupled to the second communication link comprises:

a low powered laser coupled to the eye-tracking electronics for generating an infrared eye-tracking laser beam;

eye-tracking optics coupled to the eye-tracking electronics including a lens for focusing the laser beam onto a mirror positioned to reflect the beam onto the user's eye(s), and a mirror to positioned to capture reflected energy from the user's eye(s) and direct the reflected energy through a lens to an infra photo-detector camera;

eye-tracking electronics coupled to the infrared photodetector camera for detecting distortion of the reflected laser beam energy corresponding to the eye direction vector, and generating data defining the eye direction vector for transmission through communication links to the computer subsystem; and,

a calibration subsystem coupled to the eye-tracking subsystem elements for adjusting the elements for optimal performance through the use of computer controlled actuators.

12. The invention in accordance with claim 11 wherein the HUD display subsystem coupled to the second communication link comprises:

a display screen or transparent or semi-transparent surface mounted in the field of view of the medical practitioner using the HUD for the display of images;

display optics comprising mirrors or lenses for focusing of display images on the screen or surface for viewing by the medical practitioner, including capability for superimposing the display images over the real scene being viewed through the transparent or semitransparent HUD viewing surface; and,

a display driver coupled to the second communication link for receiving display signal and generating the actual display image to be viewed by the medical practitioner.

13. The invention in accordance with claim 12 wherein the HUD audio input subsystem coupled to the second communication link comprises:

an audio input microphone mounted on the HUD to enable the user to use spoken commands to direct overall system operation or to record comments;

a speech recognition subsystem coupled to the audio microphone to recognize spoken commands and generate control signals; and,

an input command interpreter subsystem coupled to the speech recognition subsystem and the second communication link to interpret commands from the speech recognition subsystem and generate computer commands for transmission to other system elements, including at least the computer subsystem.

14. The invention in accordance with claim 13 wherein the HUD speaker subsystem coupled to the second communication link comprises:

a speaker mounted on the HUD to enable the user to hear spoken or otherwise audible commands generated by the computer subsystem or relayed by that subsystem from the external communication subsystem or information database subsystem or from the patient; and,

speaker control circuitry to adjust the speaker volume or other audio parameters for optimum performance in the working environment.

* * * * *

US005999177A

United States Patent [19]

Martinez

[11] **Patent Number: 5,999,177**

[45] **Date of Patent: *Dec. 7, 1999**

[54] **METHOD AND SYSTEM FOR CONTROLLING CONTENT ON A DISPLAY SCREEN IN A COMPUTER SYSTEM**

[75] Inventor: **Anthony Edward Martinez**, Lakeway, Tex.

[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/888,799**

[22] Filed: **Jul. 7, 1997**

[51] **Int. Cl.^{6}** **G06F 3/00**; G06F 3/14; G09G 5/34

[52] **U.S. Cl.** **345/341**; 345/342; 707/539

[58] **Field of Search** 345/340, 341, 345/342; 707/530, 539

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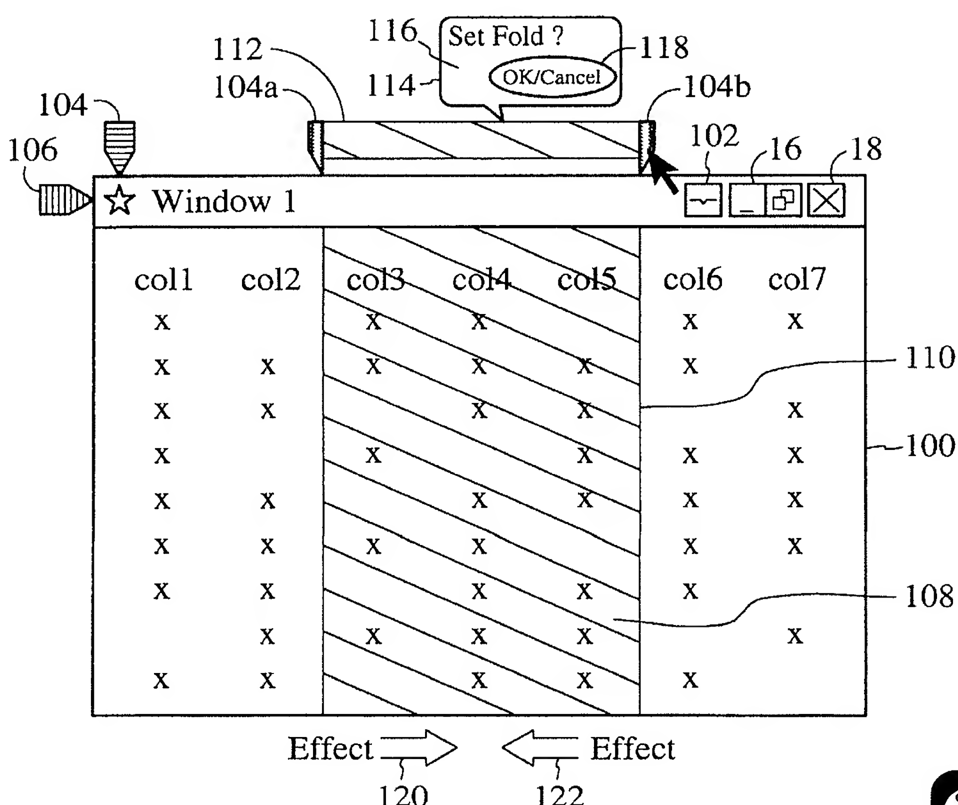
Primary Examiner—Raymond J. Bayerl
Assistant Examiner—X. L. Bautista
Attorney, Agent, or Firm—Sawyer & Associates; Volel Emile

[57] **ABSTRACT**

The present invention provides a method and system for controlling content on a display of a computer system. The method and system comprises providing at least one control element on the display, moving the at least one control element selectively between a first position and a second position on the window. The method and system further includes the content between the first and second positions. The at least one control element allows the user to "fold" windows of information like a piece of paper, at any location, to hide information that is not of interest to the user.

48 Claims, 7 Drawing Sheets



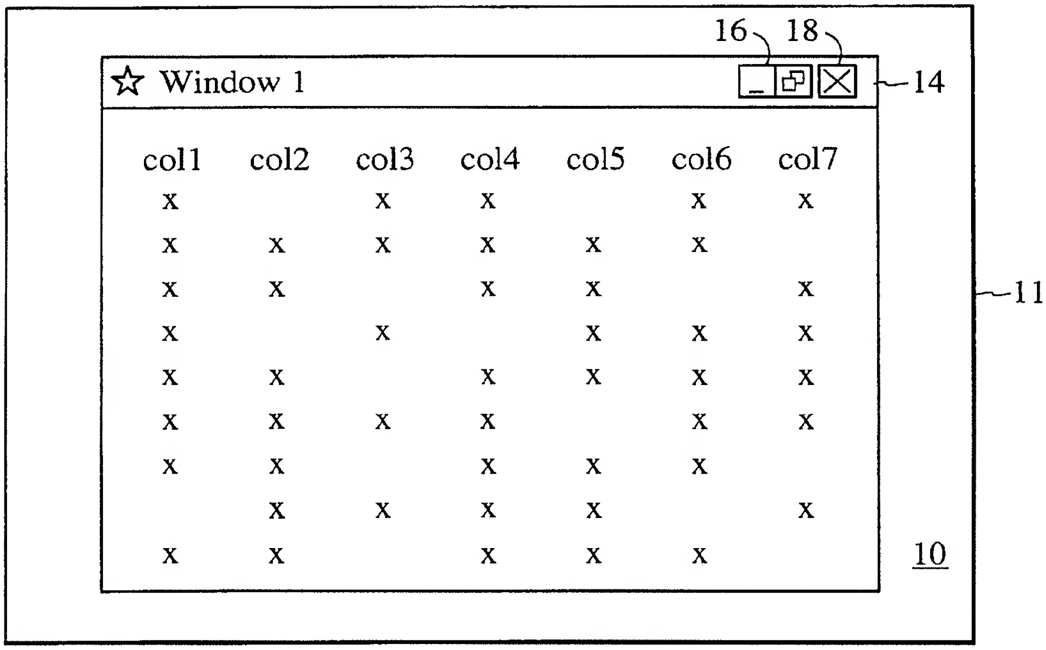

16
18
Window 1
14
col1 col2 col3 col4 col5 col6 col7
11
10

FIG. 1

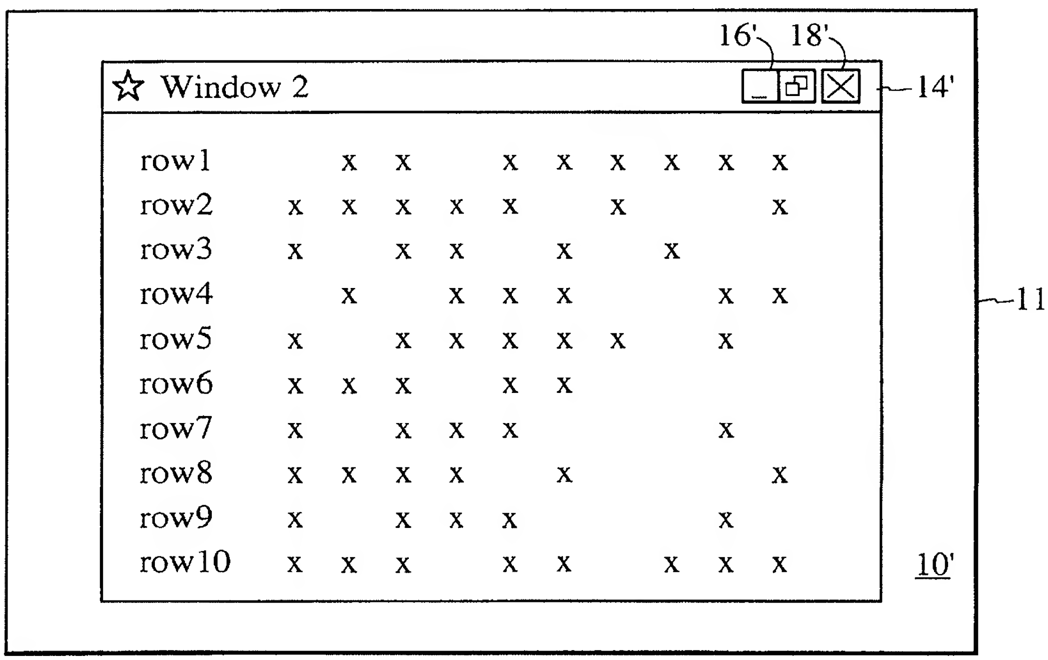

16'
18'
Window 2
14'
row1
row2
row3
row4
row5
row6
row7
row8
row9
row10
11'
10'

FIG. 2

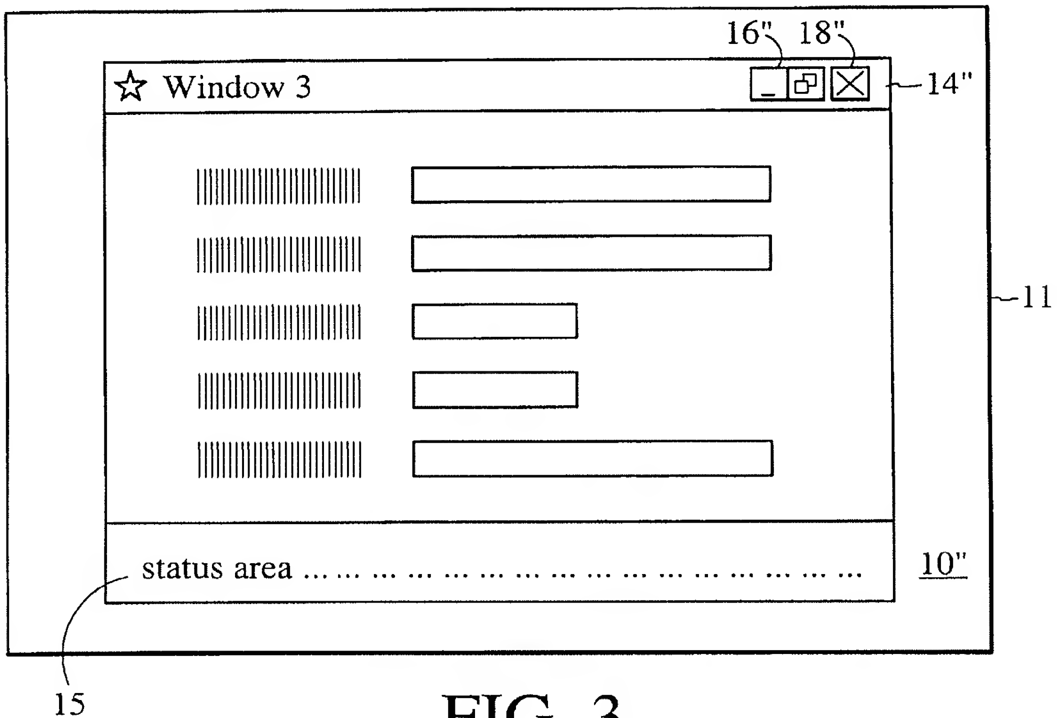

16"
18"
Window 3
14"
11"
status area ... ...
10"
15

FIG. 3

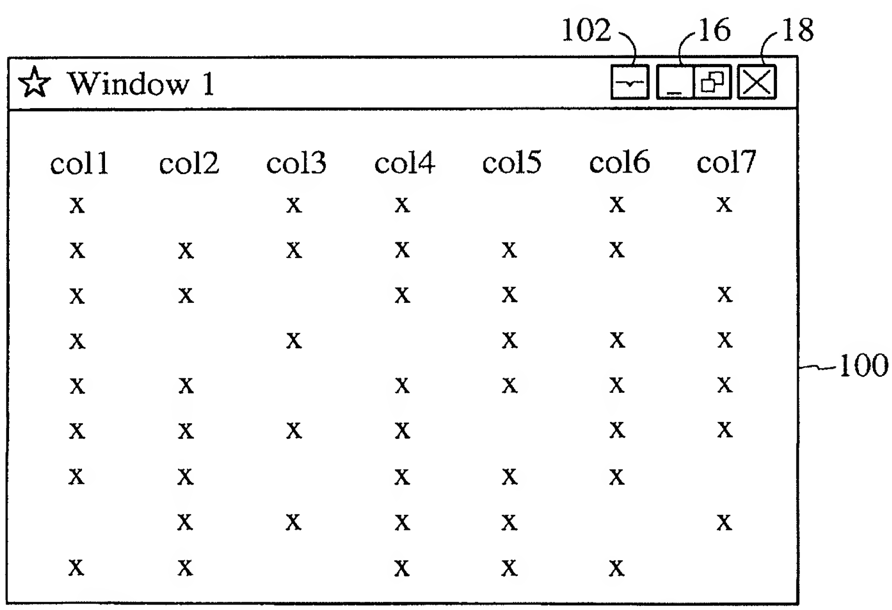

102
16
18
Window 1
col1 col2 col3 col4 col5 col6 col7
x x x x x
x x x x x x
x x x x x
x x x x x
x x x x x x
x x x x x x
x x x x x
x x x x x
x x x x x
100

FIG. 5

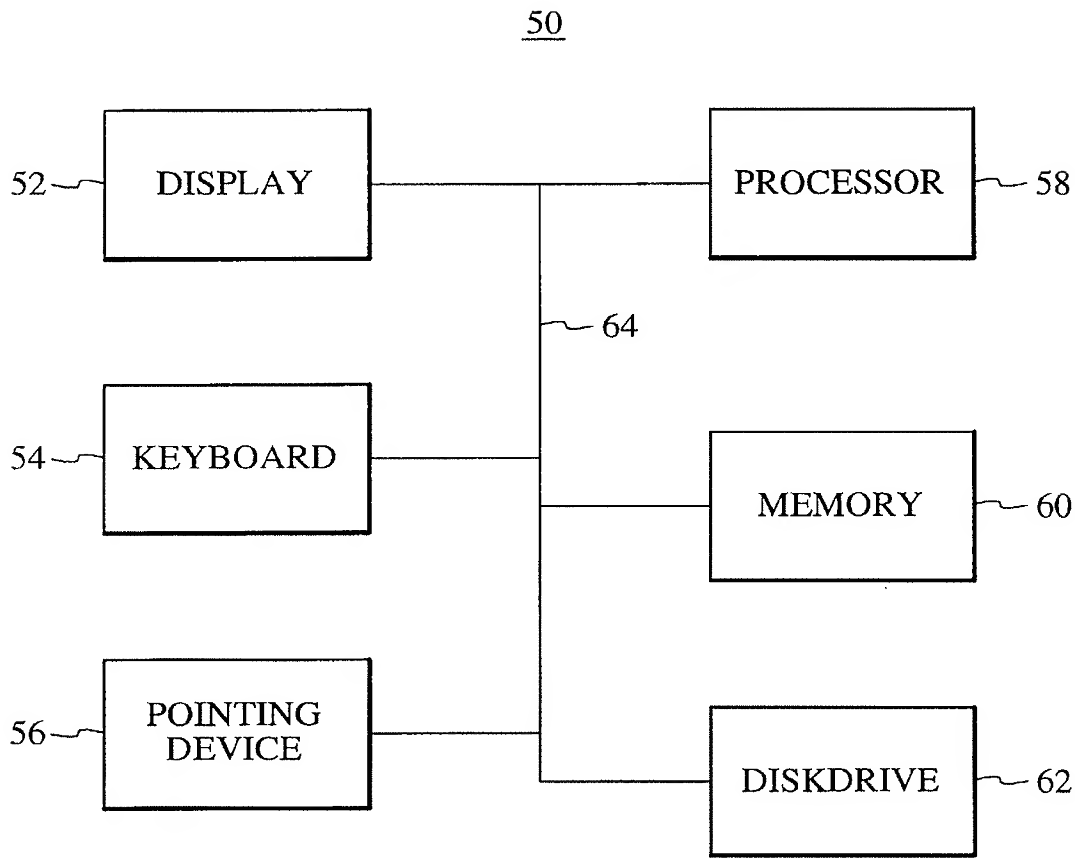

50
52
DISPLAY
54
KEYBOARD
56
POINTING DEVICE
PROCESSOR
58
64
MEMORY
60
DISKDRIVE
62

FIG. 4

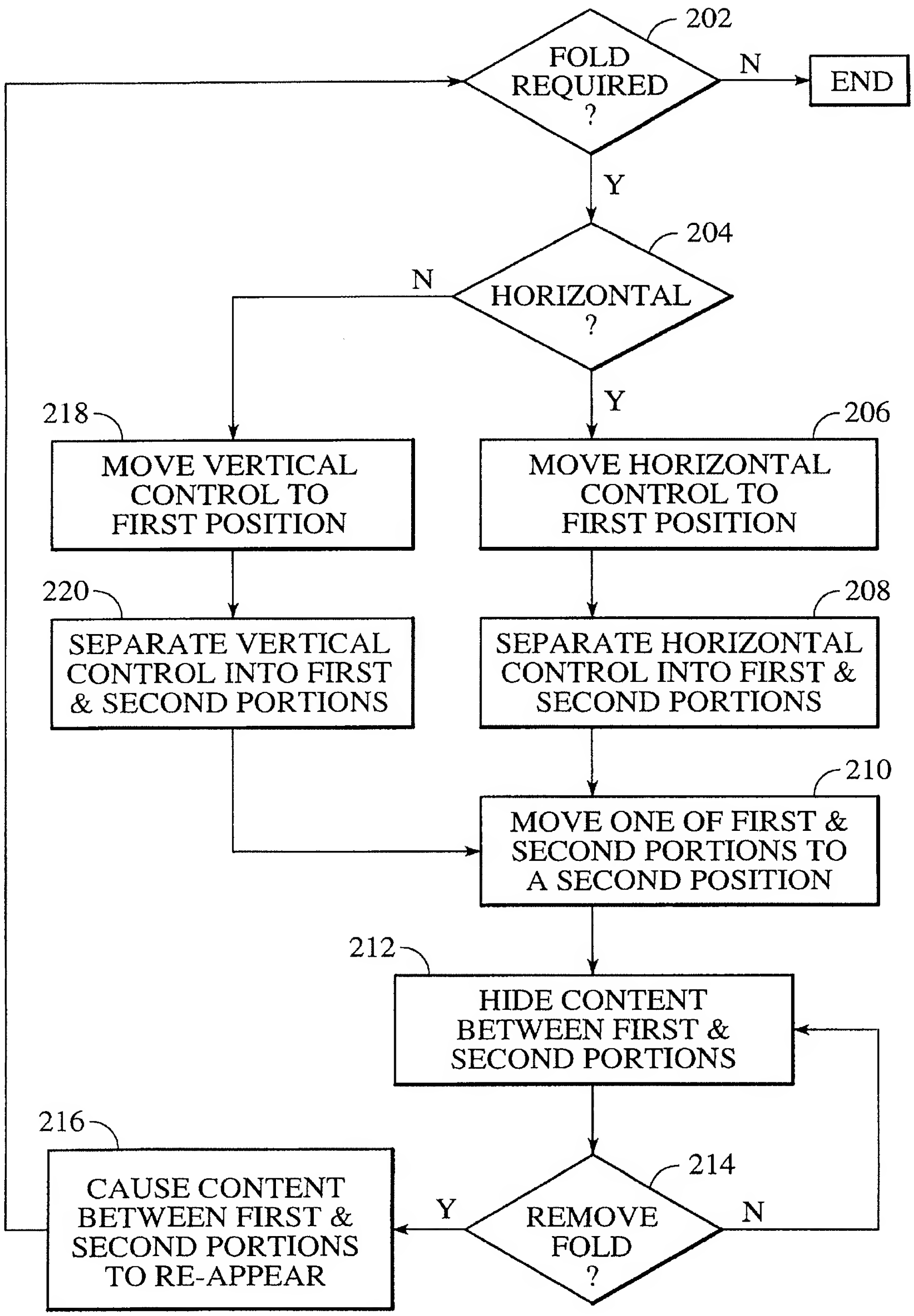

202
FOLD REQUIRED ?
N
END
Y
204
HORIZONTAL ?
N
Y
218
MOVE VERTICAL CONTROL TO FIRST POSITION
206
MOVE HORIZONTAL CONTROL TO FIRST POSITION
220
SEPARATE VERTICAL CONTROL INTO FIRST & SECOND PORTIONS
208
SEPARATE HORIZONTAL CONTROL INTO FIRST & SECOND PORTIONS
210
MOVE ONE OF FIRST & SECOND PORTIONS TO A SECOND POSITION
212
HIDE CONTENT BETWEEN FIRST & SECOND PORTIONS
216
CAUSE CONTENT BETWEEN FIRST & SECOND PORTIONS TO RE-APPEAR
Y
214
REMOVE FOLD ?
N

FIG. 6

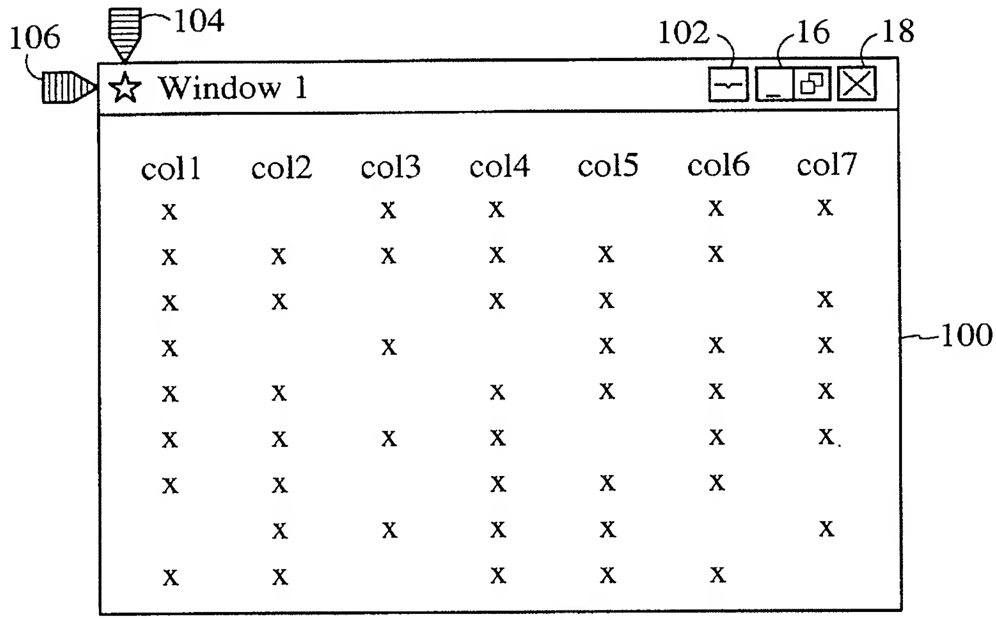

106
104
102
16
18
Window 1
col1 col2 col3 col4 col5 col6 col7
100

FIG. 7

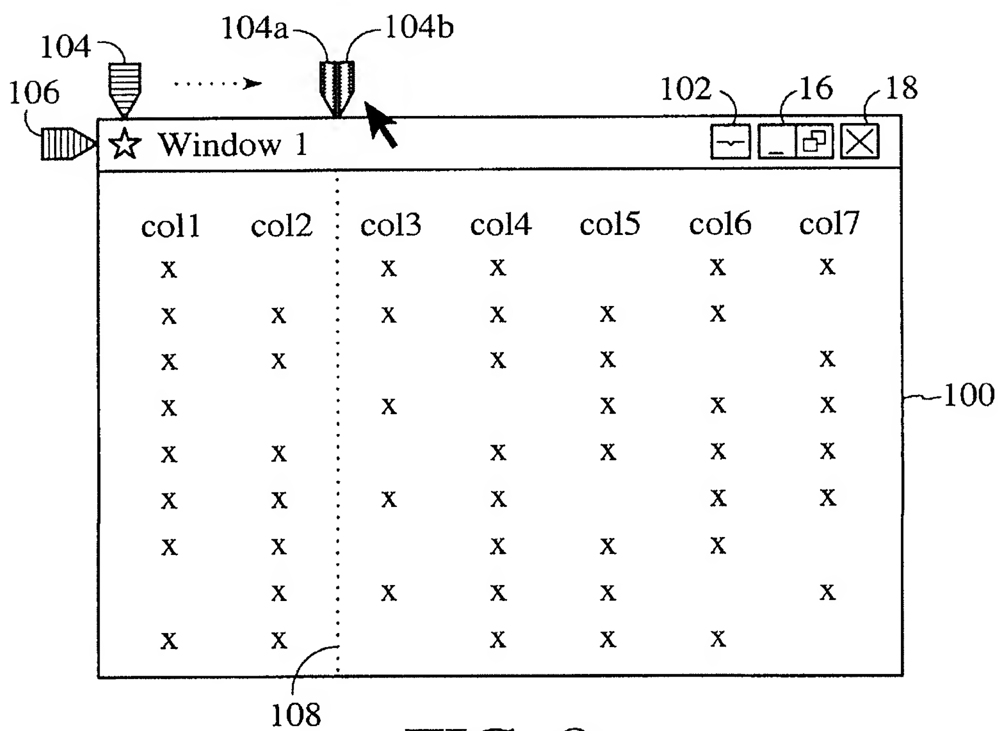

104
104a
104b
106
102
16
18
Window 1
col1 col2 col3 col4 col5 col6 col7
100
108

FIG. 8

FIG. 9

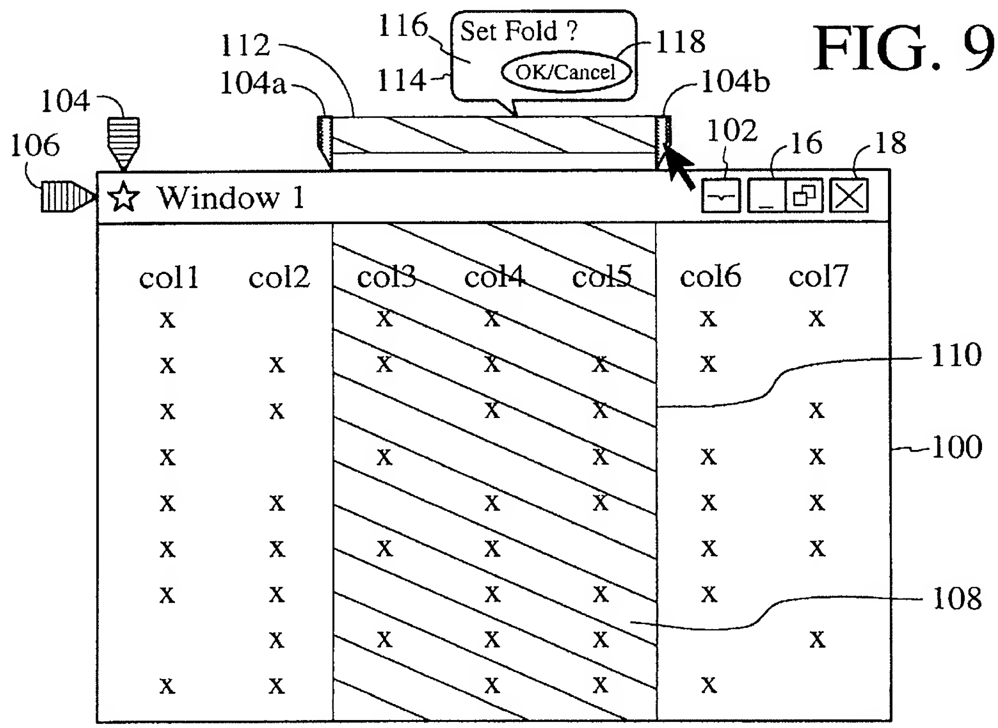
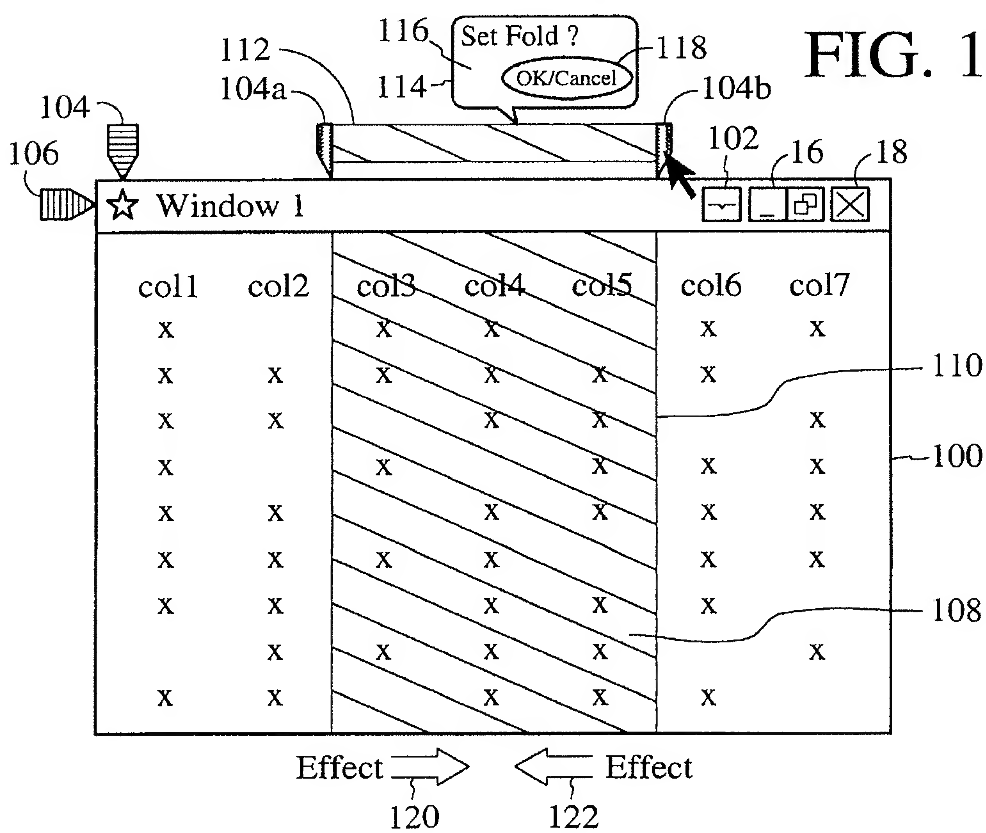

116
Set Fold ?
OK/Cancel
118
112
104a
114
104b
104
106
102
16
18
Window 1
col1
col2
col3
col4
col5
col6
col7
110
100
108

FIG. 10


116
Set Fold ?
OK/Cancel
118
112
104a
114
104b
104
106
102
16
18
Window 1
col1
col2
col3
col4
col5
col6
col7
110
100
108
Effect
120
Effect
122

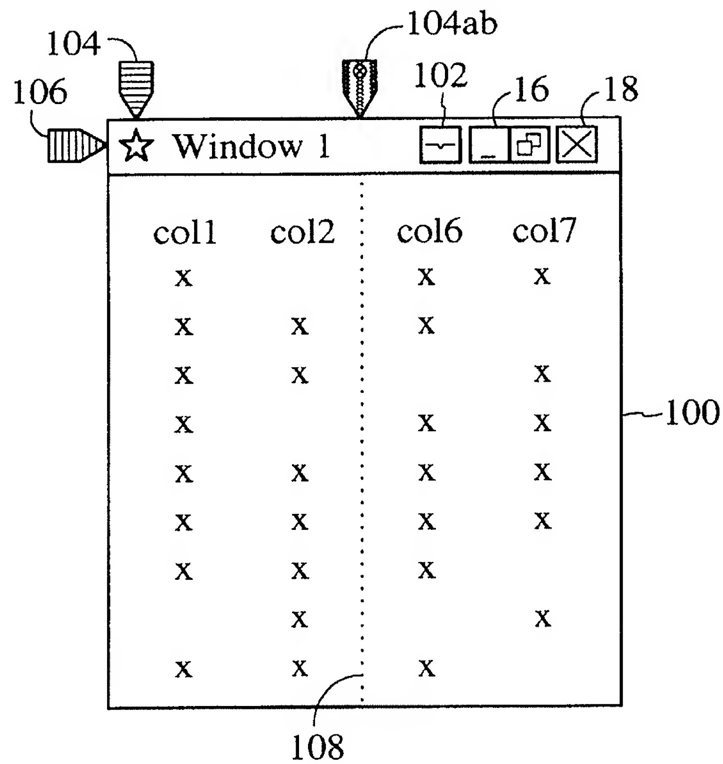

104
104ab
106
102
16
18
Window 1
col1
col2
col6
col7
100
108

FIG. 11

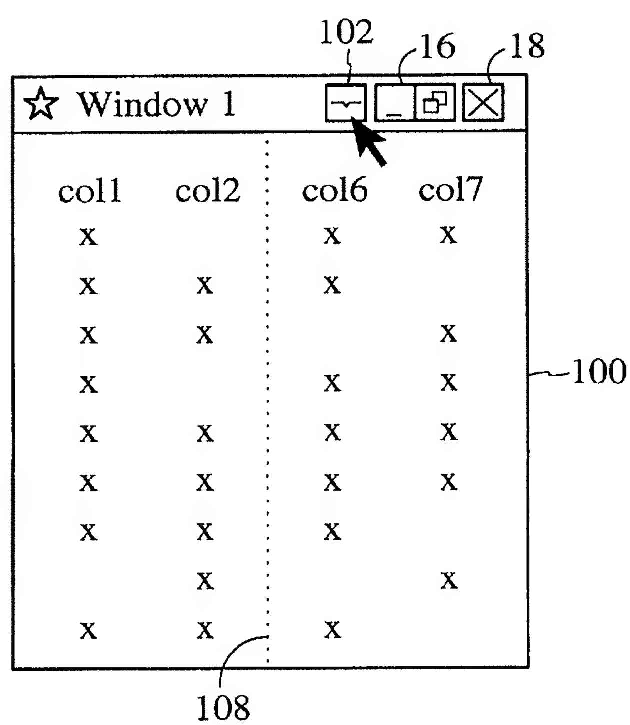

102
16
18
Window 1
col1
col2
col6
col7
100
108

FIG. 12

METHOD AND SYSTEM FOR CONTROLLING CONTENT ON A DISPLAY SCREEN IN A COMPUTER SYSTEM

FIELD OF THE INVENTION

The present invention relates generally to a computer system and more particularly to a method and system for controlling content on a display in such a computer system.

BACKGROUND OF THE INVENTION

Computers that include one or more windows on a display screen have been in existence for more than a decade. However, the amount of control that a user has over the content within the window of a display has changed very little. For example, it is known that a window on a display screen can be resized or repositioned. It is also known that resizing a window usually results in sacrificing or removing content located at the bottom, top or sides of the window. In most applications, there is very little control over what portion of the content is eliminated and the relationship of that information that has been eliminated to the rest of the content in the window.

In addition, windows that are used in conventional applications do not allow for the display of noncontiguous or nonadjacent rows and columns. To further illustrate this problem, refer now to FIGS. **1** through **3**. FIG. **1** illustrates a window **10** on a computer display **11** which displays information in columns. As is seen, columns 1 through 7 contain information in a column format. Referring now to FIG. **2**, what is shown is a window **10'** on the display **11'** which displays content a row format through rows 1 through 10. FIG. **3** illustrates a window **10"** which includes a status area **15** on a bottom portion of a window in which the information is provided in rows and columns. As is seen, each of the windows **10**, **10'** and **10"** of FIGS. **1**, **2** and **3** includes a titlebar **14** at a top portion of the window which includes control elements **16** and **18** which are traditionally used for a variety of functions. For example, the control element **16** is used to move the window around the display screen and control element **18** closes the window.

Conventional windows do not allow for flexibility when viewing content within the window. Hence, for example, it is not possible to see column 2 and column 6 side by side utilizing conventional applications. Similarly, referring now to FIG. **2**, if it is desired to view rows 3 and 9 side by side, it is not possible in conventional applications. Finally, referring to FIG. **3**, there may be a desire to remove the status area **15** because it serves no useful purpose, but once again using conventional applications it can not be eliminated.

In addition, although the FIGS. **1** through **3** show one window on a display, it is well recognized that a display screen associated with a computer system may have multiple windows thereon that are being viewed. It is desirable to selectively remove content therein to minimize the usage of "real estate", i.e. space, on the display screen when viewing multiple windows.

Accordingly, what is needed is a system and method for controlling content on a display screen in a computer system which allows for selective elimination of certain information therewithin while preserving the integrity of the information that is remaining. The system should be easy to use, should be adaptable to existing applications, and should be easy to implement. The present invention addresses these needs.

SUMMARY OF THE INVENTION

The present invention provides a method and system for controlling content on a display of a computer system. The method and system comprises providing at least one control element on the display, moving the at least one control element selectively between a first position and a second position on the window. The method and system further includes hiding the content between the first and second positions. The at least one control element allows the user to "fold" windows of information like a piece of paper, at any location, to hide information that is not of interest to the user.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view of a window showing information contained in columns.

FIG. **2** is a front view of a window showing information contained in rows.

FIG. **3** is a front view of a window showing a status area.

FIG. **4** is a block diagram of a computer system.

FIG. **5** shows a window on a display in accordance with the present invention.

FIG. **6** shows a flow chart of the operation of a fold control in accordance with the present invention.

FIGS. **7–12** show in more detail the operation of the fold control element when selectively hiding or showing columns within the window of a display.

DESCRIPTION OF THE INVENTION

The present invention relates to a method and system for controlling content on a computer display screen. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiment will be readily apparent to those skilled in the art and the generic principles herein may be applied to other embodiments. Thus, the present invention is not intended to be limited to the embodiment shown but is to be accorded the widest scope consistent with the principles and features described herein.

FIG. **4** is a block diagram of a system in which the present invention resides. The system **50** includes a display **52**, a keyboard **54**, a pointing device **56**, a processor **58**, memory **60**, and a disk drive **62**. The components of the system **50** are shown to be connected by a bus **64**.

The present invention allows for a user to control the content of a window which is displayed on a display of a computer system. In so doing, the user can review information in nonadjacent columns or rows and in the appropriate circumstance eliminate unwanted information that is within the display.

Referring now to FIG. **5**, a window **100** is shown on a display screen that includes a plurality of columns 1–7. In addition to the other control elements **16'**, **16'** and **18'**, the window **100** also includes a new control element referred to as a fold control element **102**. The fold control element **102** is utilized advantageously to create folds in the window like a piece of paper to selectively hide/show content within the display screen. To more particularly describe the use of this control, refer to the following figures in conjunction with the accompanying discussion.

To more clearly describe the operation of the fold control **102**, refer now to FIG. **6**, which is a flow chart of the operation of the flow control in accordance with the present invention. First, it is determined if a fold is required, via step **202**. Then the next step is to determine whether the fold is horizontal, via step **204**. If the fold is to be horizontal, then

a copy of a horizontal control element is moved to a first position on the display, via step **206**. Next the control element separates into a first and second portions, via step **208**. Thereafter one of the first and second portions of the horizontal control element is moved to a second position on the display, via step **210**, and finally, the content between the first and second positions is hidden, via step **212**. Next, it is determined if the fold is to be removed, via step **214**. If it is not to be removed, return to step **216**. If it is to be removed, then the content between the first and second portions should reappear. Similarly, if it is a vertical fold, via step **214**, the vertical fold control element is moved to a first vertical position on the display, via step **218**. Next, the horizontal element is separated into first and second vertical portions, via step **220**. Next, one of the first and second portions of the horizontal control element is moved to a second horizontal position, via step **210**, and then the content between the first and second positions is hidden, via step **212**. Finally, steps **214** and **216** are repeated as described above.

FIGS. **7–12** show in more detail the operation of the fold control element **102** when selectively hiding or showing columns within the window of a display. Initially, as is seen, in FIG. **7**, the fold control element is pressed and in this embodiment two control elements **104** and **106** are shown. In this embodiment, control element **104** is utilized to provide a horizontal fold. Control element **106** provides a vertical fold. First the horizontal fold control will be described.

As is seen in FIG. **8**, first a copy of the control element **104** is moved a predetermined distance. In this embodiment, the fold is begun between columns 2 and 3. The movement of the copy of the control elements **104** and **106** can be accomplished in a variety of fashions, for example, by using a mouse (not shown) to drag the control to the right, using some type of pointing device (not shown) or some other device to provide the beginning of the fold. As is also seen, in a preferred embodiment, there is a dotted line **108** which will indicate the boundary of the area that is being hidden. When the initial move is completed, as is seen in the figure, the copy of the fold control element **104** changes in appearance by splitting in the middle, into a first and second portions **104***a* and **104***b*.

Referring now to FIG. **9**, once it is determined that the beginning position of first and second portions **104***a* and **104***b* is correct, then the first or second portion **104***a* and **104***b* can be moved to finish the fold. It should be recognized that the separation of the control element **104** into two portions and the subsequent movement of one of the portions is an optional step. For example, the control element **104** could be set at a first position and then by some user interaction, such a mouse click, a first position of the fold is set. Thereafter the control element **104** could be set at a second position, then by a user interaction a second position of the fold is set.

In this embodiment, the second portion **104***b* is moved to a second position between columns 5 and 6. As is also seen, the dotted line **108** moves to a mid-point between the first and second portions **104***a* and **104***b* . In a preferred embodiment there is a shaded area **110** indicated between columns 2–6. In addition there is a shaded area **112** between the first and second portions **104***a* and **104***b* of the control element **104**. The shaded area **110** indicates the content to be hidden. When the second position is set, in a preferred embodiment a set fold dialog box **114** pops up. This dialog box **114** is utilized to indicate whether the fold is to be made or not within the window **100**. Accordingly, in this embodiment, if the OK button **116** is pressed, the fold can be made. If the cancel button **118** is pressed, then the shaded area will be eliminated and the fold control will be reset. Until one of the buttons are pressed on the set fold dialog box **114**, the shaded areas **108** and **112** can be increased or decreased in whatever manner the user desires.

Referring now to FIG. **10**, as is seen when OK is pressed on the dialog box **114**, the fold is activated preferably with a visual effect of moving inward as shown by the arrows **120** and **122**. Referring now to FIG. **11**, the marked area between columns 2 and 6 is now hidden. Only the dotted line **108** remains to indicate the presence of a fold. As is also seen, the copy of the horizontal fold control element **104** is one element. As is also seen, the copy of the horizontal fold control **104** has an X therewithin providing a further indication that a fold is provided. In a embodiment, the X can be pressed to restore the original content.

In FIG. **11**, as is seen, the fold control element **104** easily allows one to compare nonadjacent columns of information. Referring now to FIG. **12**, the fold control element **104** and its copy can can be removed by clicking or pressing on the fold control **102**. In addition, the same type of procedure could be followed with the vertical fold control element **106** to hide the contents between nonadjacent rows.

Accordingly a system and method is provided that allows a user to "fold" content within a window like a piece of paper to selectively hide and reveal content. Through a system and method in accordance with the present invention, related nonadjacent information can be easily viewed. In addition, valuable real estate within a display of a computer system can be saved by eliminating unuseful information, such a status bars and the like.

Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations to the embodiments and those variations would be within the spirit and scope of the present invention. For example, although a copy of the vertical and horizontal fold control elements **104** and **106** are utilized to create the fold, it is clear that the fold control elements could be used to create the folds. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the appended claims.

What is claimed is:

1. A method of selectively controlling content within a window on a display of a computer system, comprising the steps of:

(a) providing at least one control element on the window;

(b) separating the at least one control element into first and second portions;

(c) moving one of the first and second portions to a second position on the window; and

(d) hiding the content between the first and second positions.

2. The method of claim **1** wherein the moving step (b) includes the steps of:

(b1) separating the at least one control element into first and second portions; and

(b2) moving one of the first and second portions to a second position on the window.

3. The method of claim **2** wherein the vertical fold control element causes the content between a first and second vertical positions of the window to be hidden.

4. The method of claim **3** wherein the content between the first and second vertical positions is shaded.

5. The method of claim **4** wherein the first position includes a line for providing a fold position.

6. The method of claim **5** wherein the line moves based upon movement of one of a first and second portions of the vertical fold control element.

7. The method of claim **6** wherein the line is dotted.

8. The method of claim **7** wherein the fold position is based upon being between a mid-point of the first and second portions of the vertical control element.

9. The method of claim **8** wherein a copy of the at least one control element is utilized to provide the fold.

10. The method of claim **2** wherein the horizontal fold control element causes the content between the first and second horizontal positions of the window to be hidden.

11. The method of claim **10** wherein the content between the first and second horizontal positions is shaded.

12. The method of claim **11** wherein the first position includes a line for providing a fold position.

13. The method of claim **12** wherein the line moves are based upon movement of one of a first and second portions of the horizontal fold control element.

14. The method of claim **13** wherein the line is dotted.

15. The method of claim **14** wherein the fold position is based upon being between a mid-point of the first and second portions of the horizontal control element.

16. The method of claim **15** wherein a copy of the at least one control element is utilized to provide the fold.

17. A system of selectively controlling content within a window on a display of a computer system, comprising:

means for providing at least one control element on the window;

means for separating the at least one control element into first and second portions;

means for moving one of the first and second portions to a second position on the window;

means for hiding the content between the first and second positions.

18. The system of claim **17** in which the providing means comprises:

means for providing a horizontal fold control element; and

means for providing a vertical fold control element.

19. The system of claim **18** wherein the vertical fold control element causes the content between a first and second vertical positions of the window to be hidden.

20. The system of claim **19** wherein the content between the first and second vertical positions is shaded.

21. The system of claim **20** wherein the first position includes a line for providing a fold position.

22. The system of claim **21** wherein the line moves based upon movement of one of a first and second portions of the vertical fold control element.

23. The system of claim **22** wherein the line is dotted.

24. The system of claim **23** wherein the fold position is based upon being between a mid-point of the first and second portions of the vertical control element.

25. The system of claim **24** wherein a copy of the at least one control element is utilized to provide the fold.

26. The system of claim **18** wherein the horizontal fold control element causes the content between the first and second horizontal positions of the window to be hidden.

27. The system of claim **26** wherein the content between the first and second horizontal positions is shaded.

28. The system of claim **27** wherein the first position includes a line for providing a fold position.

29. The system of claim **28** wherein the line moves are based upon movement of one of a first and second portions of the horizontal fold control element.

30. The system of claim **29** wherein the line is dotted.

31. The system of claim **30** wherein the fold position is based upon being between a mid-point of the first and second portions of the horizontal control element.

32. The system of claim **31** wherein a copy of the at least one control element is utilized to provide the fold.

33. A method of selectively controlling content within a window on a display of a computer system, comprising the steps of:

(a) providing a horizontal fold control element;

(b) providing a vertical fold control element, wherein the vertical fold control element causes the content between a first and second vertical positions of the window to be hidden, wherein the content between the first and second vertical positions is shaded, wherein the first position includes a line for providing a fold position, wherein the line moves based upon movement of one of a first and second portions of the vertical fold control element;

(c) moving the horizontal fold control element and the vertical fold control element selectively between a first position and a second position on the window; and

(d) hiding the content between the first and second positions.

34. The method of claim **33** wherein the line is dotted.

35. The method of claim **34** wherein the fold position is based upon being between a mid-point of the first and second portions of the vertical control element.

36. The method of claim **35** wherein a copy of the at least one control element is utilized to provide the fold.

37. A method of selectively controlling content within a window on a display of a computer system, comprising the steps of:

(a) providing a horizontal fold control element, wherein the horizontal fold control element causes the content between a first and second horizontal positions of the window to be hidden, wherein the content between the first and second horizontal positions is shaded, wherein the first position includes a line for providing a fold position, wherein the line moves based upon movement of one of a first and second portions of the horizontal fold control element;

(b) providing a vertical fold control element;

(c) moving at least the horizontal fold control element or the vertical fold control element selectively between a first position and a second position on the window; and

(d) hiding the content between the first and second positions.

means for hiding the content between the first and second positions.

38. The method of claim **37** wherein the line is dotted.

39. The method of claim **38** wherein the fold position is based upon being between a mid-point of the first and second portions of the horizontal control element.

40. The method of claim **39** wherein a copy of the at least one control element is utilized to provide the fold.

41. A system of selectively controlling content within a window on a display of a computer system, comprising:

means for providing a horizontal fold control element;

means for providing a vertical fold control element, wherein the vertical fold control element causes the content between a first and second vertical positions of the window to be hidden, wherein the content between the first and second vertical positions is shaded, wherein the first position includes a line for providing

a fold position, wherein the line moves based upon movement of one of a first and second portions of the vertical fold control element;

means for moving at least the first or the second portions to a second position on the window;

means for hiding the content between the first and second positions.

42. The system of claim **41** wherein the line is dotted.

43. The system of claim **42** wherein the fold position is based upon being between a mid-point of the first and second portions of the vertical control element.

44. The system of claim **43** wherein a copy of the at least one control element is utilized to provide the fold.

45. A system of selectively controlling content within a window on a display of a computer system, comprising:

means for providing a horizontal fold control element, wherein the horizontal fold control element causes the content between a first and second horizontal positions of the window to be hidden, wherein the content between the first and second horizontal positions is shaded, wherein the first position includes a line for providing a fold position, wherein the line moves based upon movement of one of a first and second portions of the horizontal fold control element;

means for providing a vertical fold control element;

means for moving at least the first or the second portions to a second position on the window;

means for hiding the content between the first and second positions.

46. The system of claim **45** wherein the line is dotted.

47. The system of claim **46** wherein the fold position is based upon being between a mid-point of the first and second portions of the horizontal control element.

48. The system of claim **47** wherein a copy of the at least one control element is utilized to provide the fold.

* * * * *

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(12) **United States Patent**
Mitchell et al.

(10) **Patent No.:** **US 6,983,331 B1**
(45) **Date of Patent:** **Jan. 3, 2006**

(54) **SELECTIVE DISPLAY OF CONTENT**

(75) Inventors: **Syne Mitchell**, North Bend, WA (US); **G. Scott Tomlin**, Bellevue, WA (US); **Lori Niva**, Issaquah, WA (US); **Matthew J. Lindenburg**, Seattle, WA (US)

(73) Assignee: **Microsoft Corporation**, Redmond, WA (US)

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(58) **Field of Classification Search** 709/217, 709/203, 246; 715/513, 517
See application file for complete search history.

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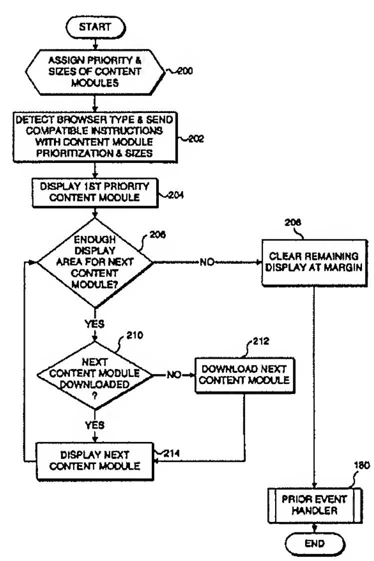
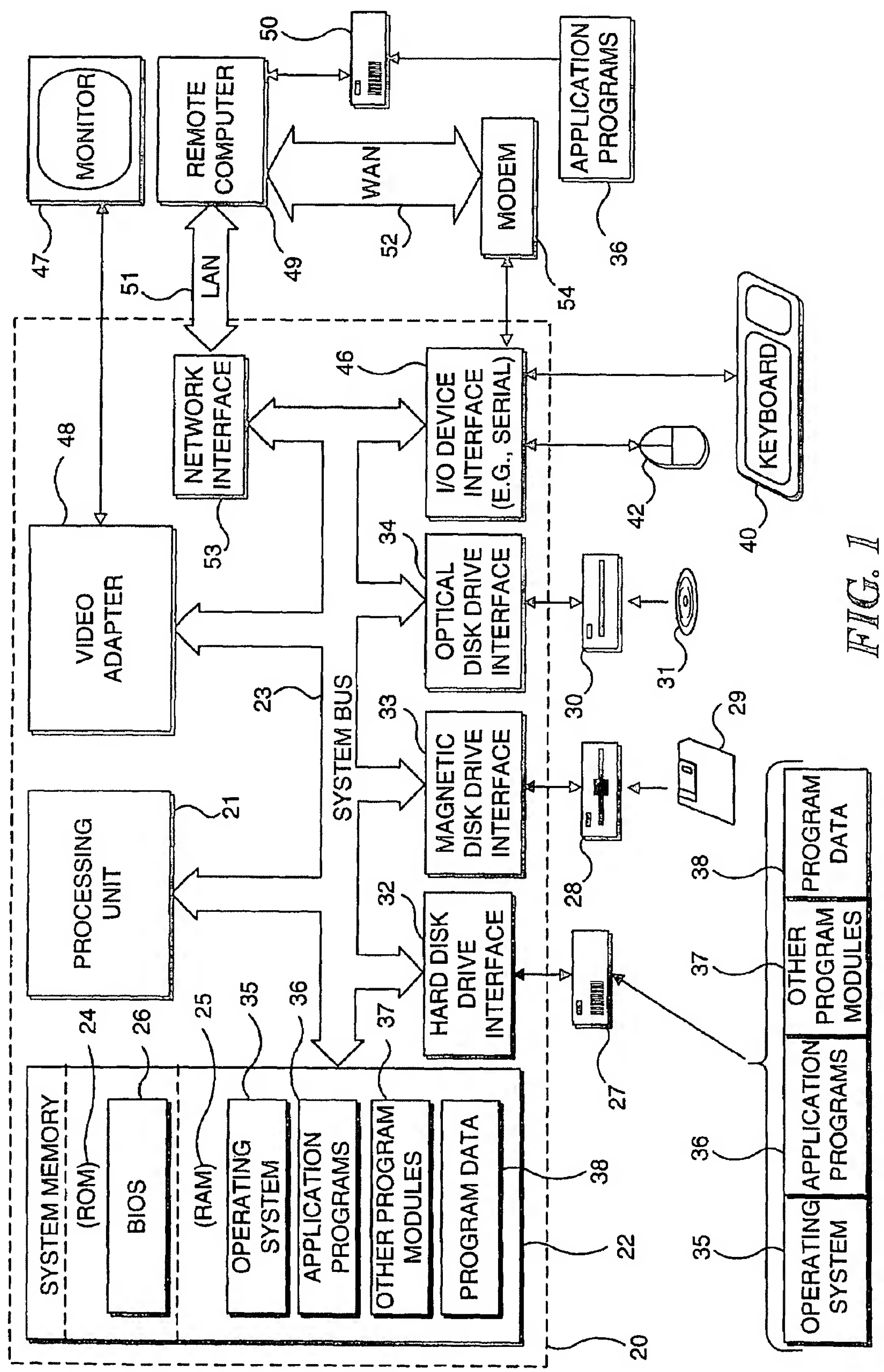
Primary Examiner—Bharat Barot
Assistant Examiner—David Lazaro
(74) *Attorney, Agent, or Firm*—Ronald M. Anderson

(57) **ABSTRACT**

A method and system for selectively fully displaying additional content in a browser window, without requiring scrolling in more than one direction, based on an available display area. For example, additional advertising content is thus selectively displayed in an otherwise unused area of the browsing window to the right of a primary content of a Web page. The size of the available display area is automatically detected, and a determination is automatically made as to whether the additional content and primary content can both be fully displayed in the available display area under the scrolling constraint. If so, both the additional content and the primary content are displayed. Otherwise, only the primary content is displayed. The additional content is downloaded only when it can thus be included within the display area. If the browser window is resized so that the additional content no longer fits without scrolling in more than one direction, the additional content is removed from the display, but is preferably retained in local storage for redisplay if the available display area is subsequently increased sufficiently. The type (and version) of browser program used is detected so that the appropriate instructions will be provided to the client device to selectively display additional content in this manner. For smaller client device displays, such as on those on pocket PCs, the content provided by a server is selectively determined in a prioritized manner, as a function of the available display area.

6 Claims, 13 Drawing Sheets





MONITOR
REMOTE COMPUTER
APPLICATION PROGRAMS
WAN
MODEM
LAN
NETWORK INTERFACE
VIDEO ADAPTER
PROCESSING UNIT
SYSTEM BUS
I/O DEVICE INTERFACE (E.G., SERIAL)
OPTICAL DISK DRIVE INTERFACE
MAGNETIC DISK DRIVE INTERFACE
HARD DISK DRIVE INTERFACE
KEYBOARD
SYSTEM MEMORY
(ROM)
BIOS
(RAM)
OPERATING SYSTEM
APPLICATION PROGRAMS
OTHER PROGRAM MODULES
PROGRAM DATA
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
40
42
46
47
48
49
50
51
52
53
54

FIG. 1

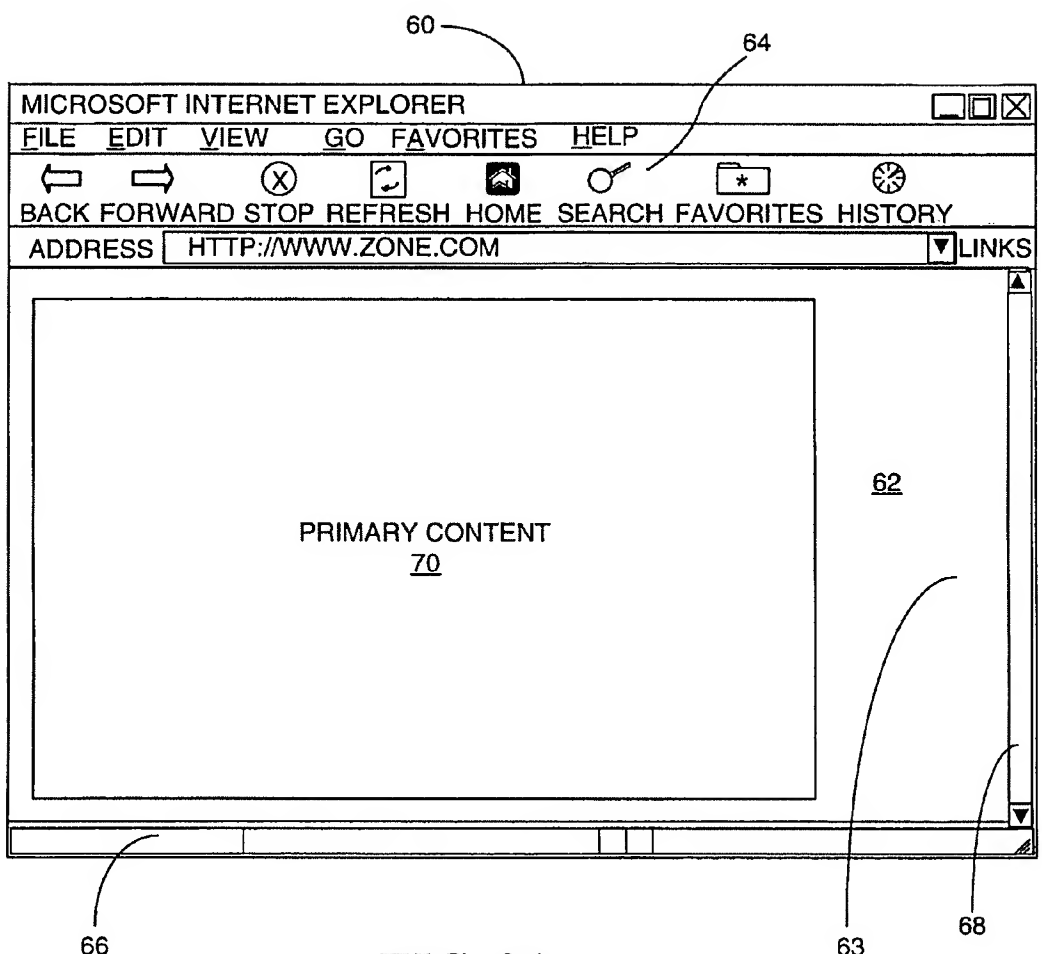
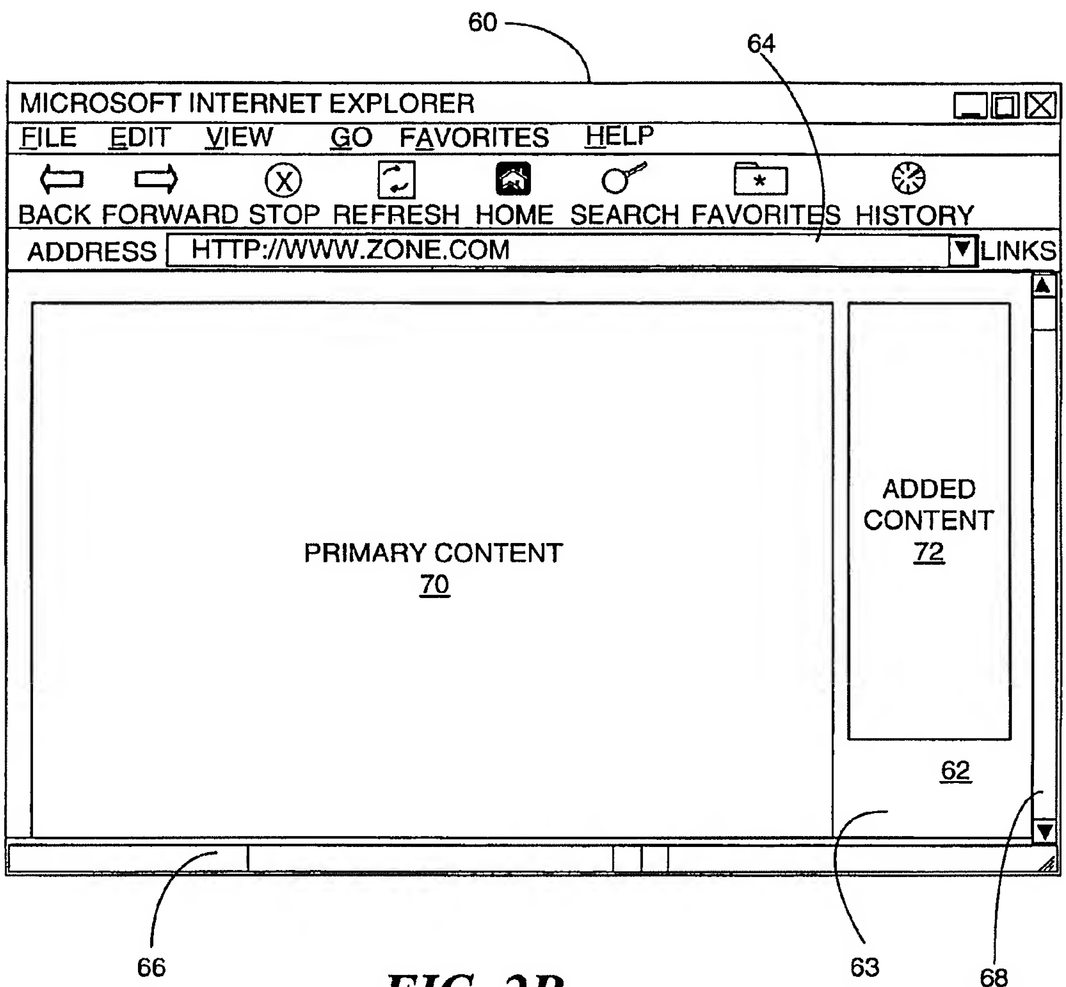

60
64
MICROSOFT INTERNET EXPLORER
FILE EDIT VIEW GO FAVORITES HELP
BACK FORWARD STOP REFRESH HOME SEARCH FAVORITES HISTORY
ADDRESS HTTP://WWW.ZONE.COM
LINKS
62
PRIMARY CONTENT
70
66
63
68

FIG. 2A



60
64
MICROSOFT INTERNET EXPLORER
FILE EDIT VIEW GO FAVORITES HELP
BACK FORWARD STOP REFRESH HOME SEARCH FAVORITES HISTORY
ADDRESS HTTP://WWW.ZONE.COM
LINKS
PRIMARY CONTENT 70
ADDED CONTENT 72
62
66
63
68

FIG. 2B

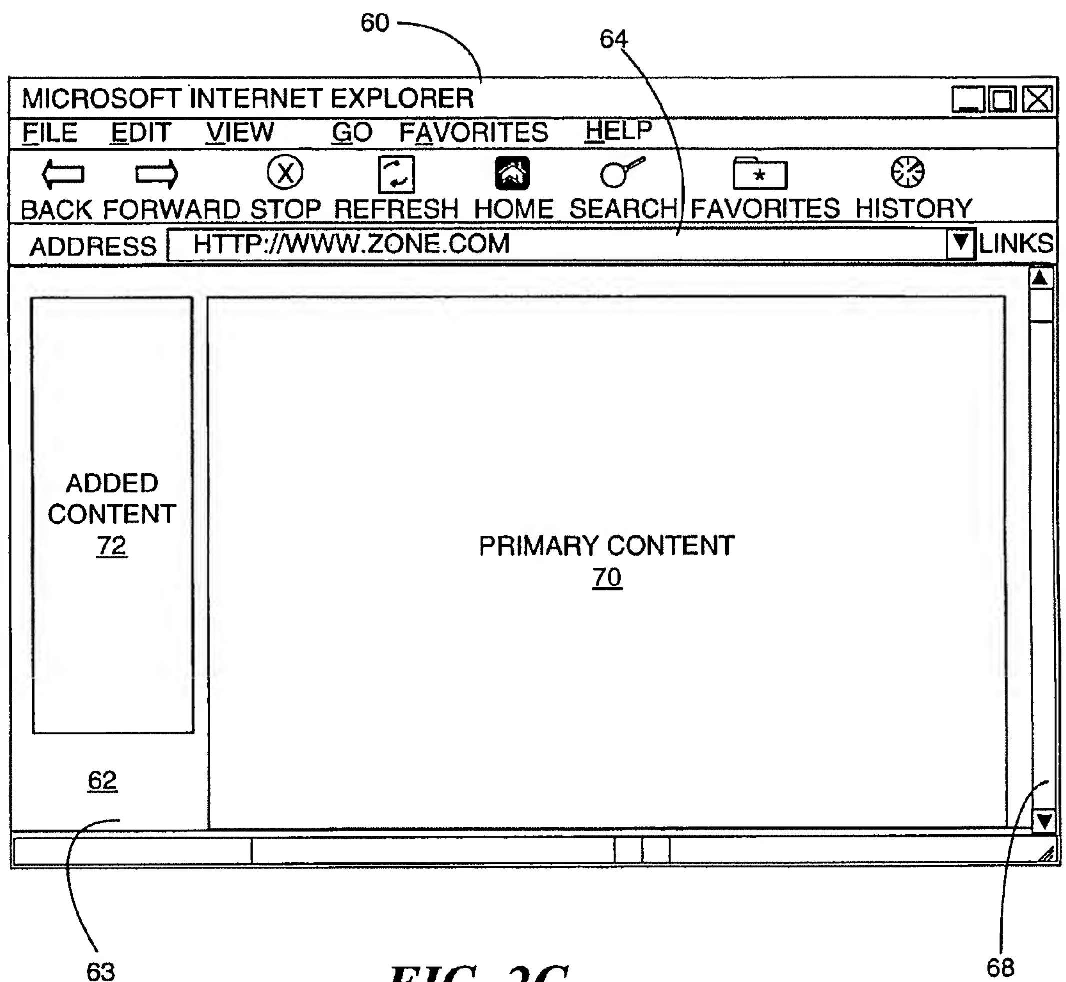

60
64
MICROSOFT INTERNET EXPLORER
FILE EDIT VIEW GO FAVORITES HELP
BACK FORWARD STOP REFRESH HOME SEARCH FAVORITES HISTORY
ADDRESS HTTP://WWW.ZONE.COM
LINKS
ADDED CONTENT 72
PRIMARY CONTENT 70
62
63
68

FIG. 2C

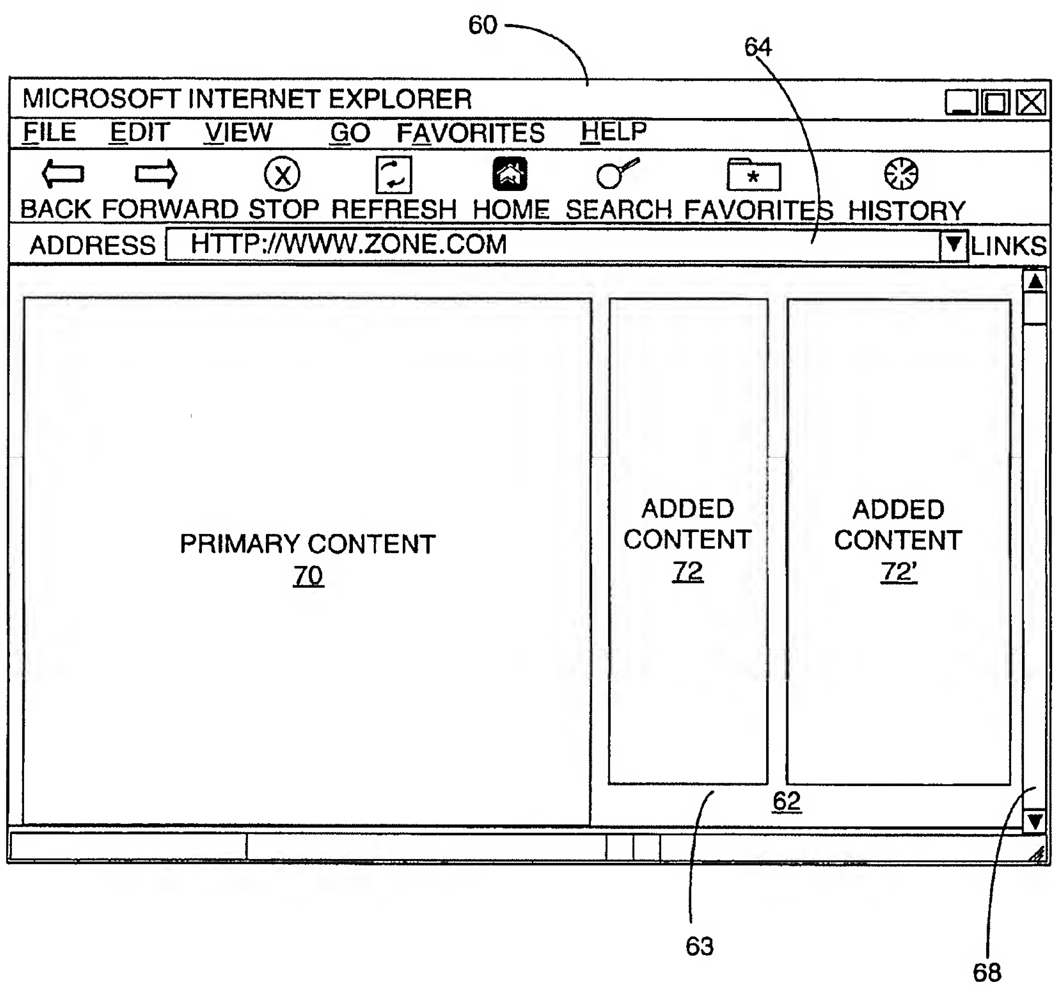

60
64
MICROSOFT INTERNET EXPLORER
FILE EDIT VIEW GO FAVORITES HELP
BACK FORWARD STOP REFRESH HOME SEARCH FAVORITES HISTORY
ADDRESS HTTP://WWW.ZONE.COM
LINKS
PRIMARY CONTENT
70
ADDED CONTENT
72
ADDED CONTENT
72'
62
63
68

FIG. 2D

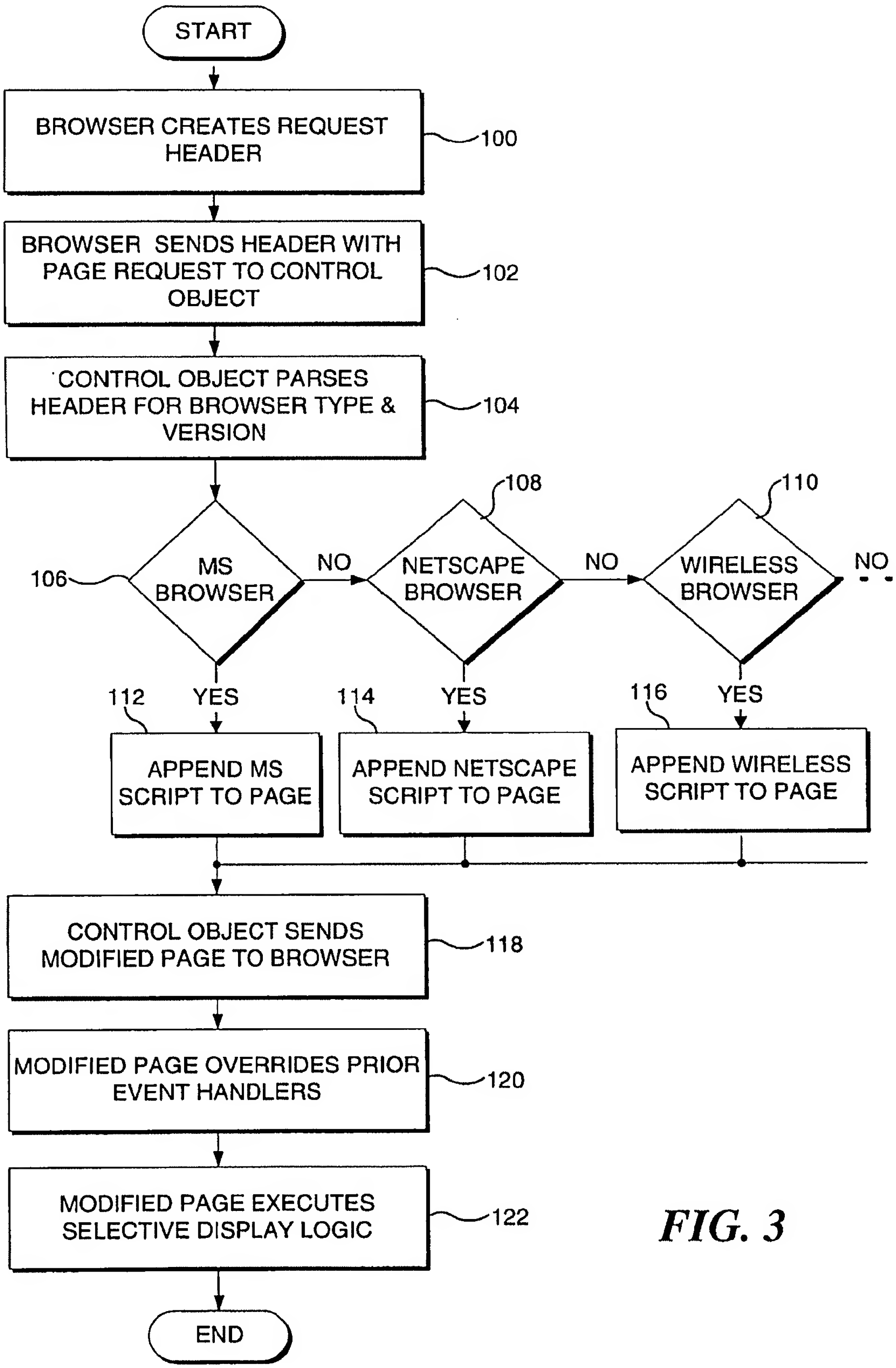

START
BROWSER CREATES REQUEST HEADER
100
BROWSER SENDS HEADER WITH PAGE REQUEST TO CONTROL OBJECT
102
CONTROL OBJECT PARSES HEADER FOR BROWSER TYPE & VERSION
104
106
MS BROWSER
NO
108
NETSCAPE BROWSER
NO
110
WIRELESS BROWSER
NO
112
YES
114
YES
116
YES
APPEND MS SCRIPT TO PAGE
APPEND NETSCAPE SCRIPT TO PAGE
APPEND WIRELESS SCRIPT TO PAGE
CONTROL OBJECT SENDS MODIFIED PAGE TO BROWSER
118
MODIFIED PAGE OVERRIDES PRIOR EVENT HANDLERS
120
MODIFIED PAGE EXECUTES SELECTIVE DISPLAY LOGIC
122
END

FIG. 3

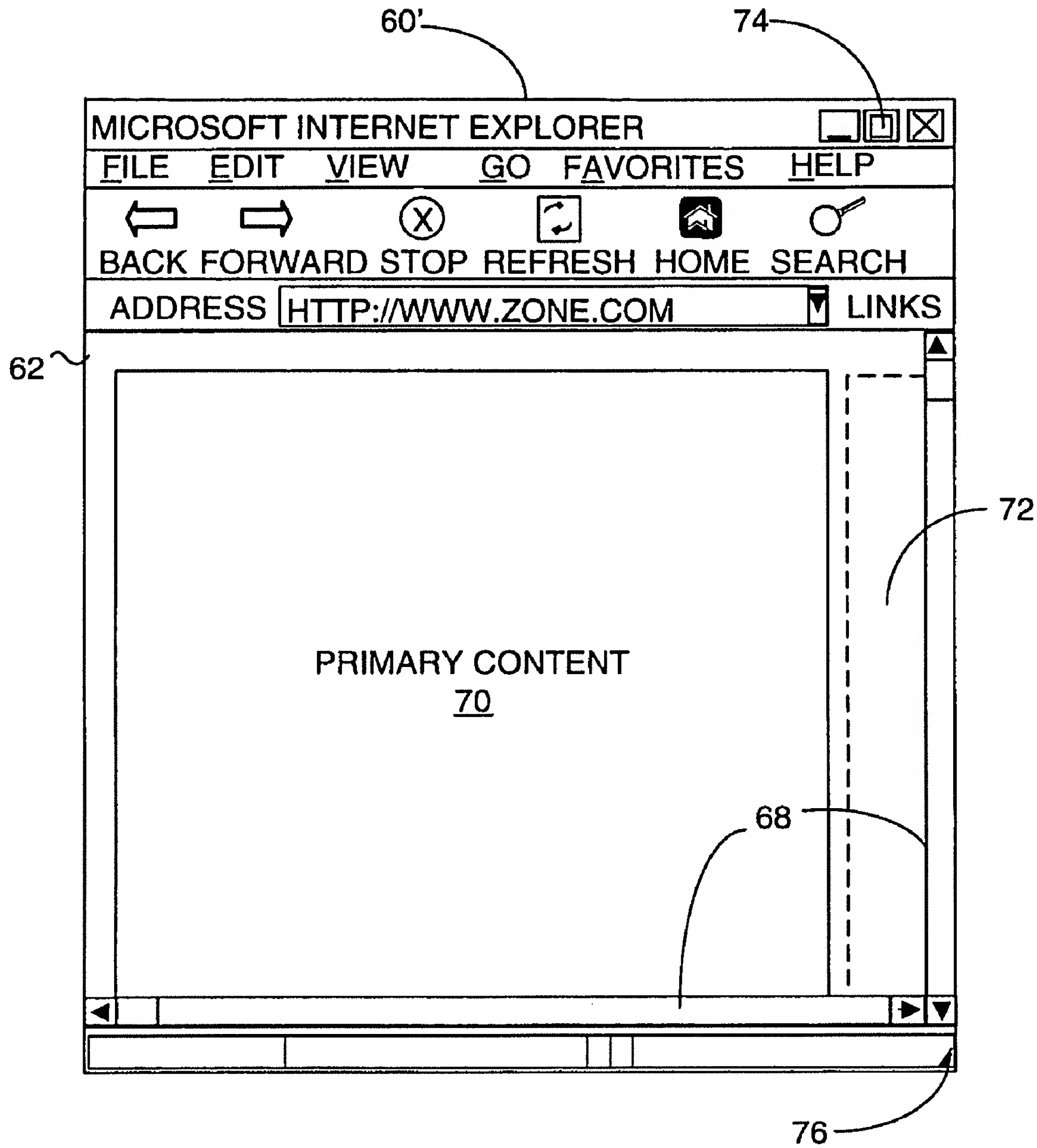

60'
74
MICROSOFT INTERNET EXPLORER
FILE EDIT VIEW GO FAVORITES HELP
BACK FORWARD STOP REFRESH HOME SEARCH
ADDRESS HTTP://WWW.ZONE.COM LINKS
62
72
PRIMARY CONTENT
70
68
76

FIG. 2E

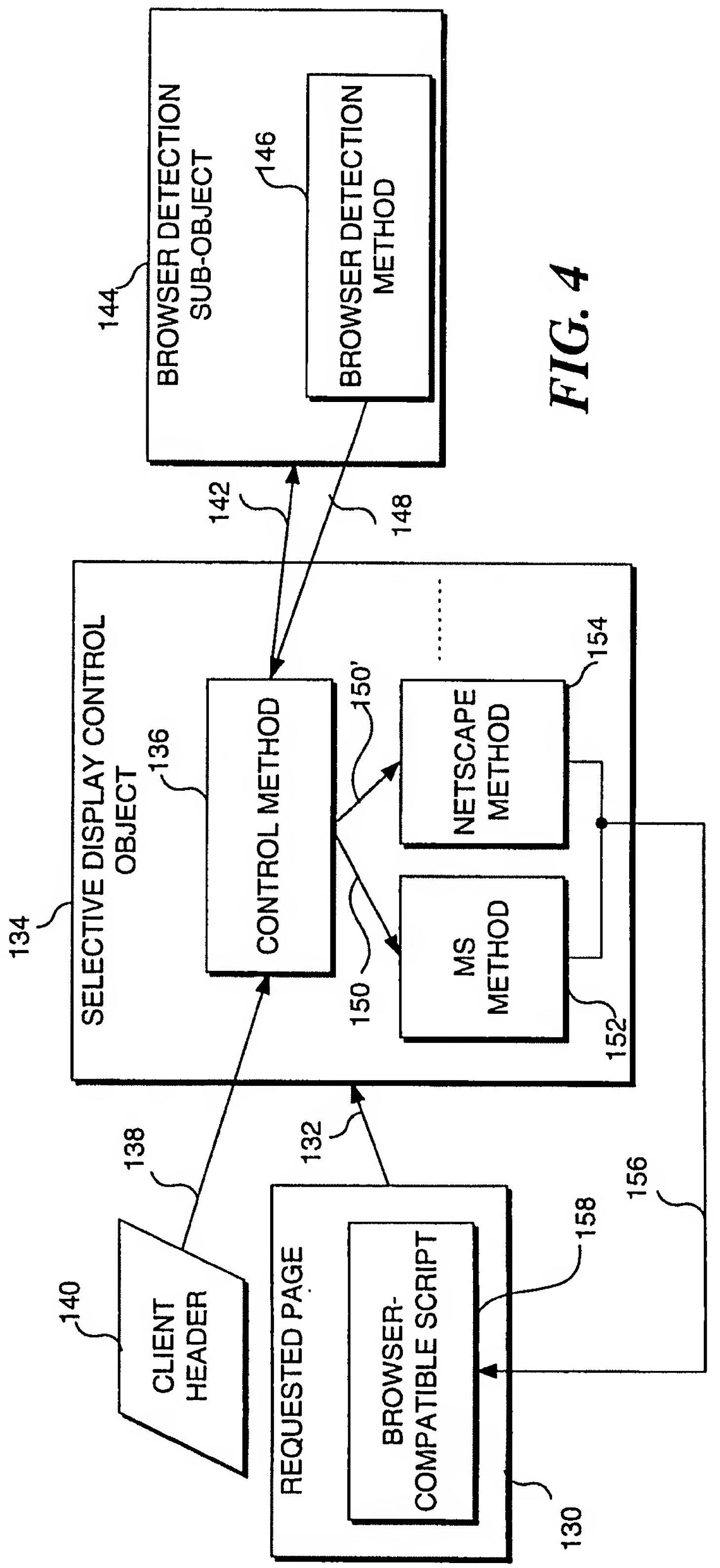

BROWSER DETECTION SUB-OBJECT
144
BROWSER DETECTION METHOD
146
142
148
SELECTIVE DISPLAY CONTROL OBJECT
134
CONTROL METHOD
136
150'
150
NETSCAPE METHOD
154
MS METHOD
152
CLIENT HEADER
140
138
132
REQUESTED PAGE
BROWSER-COMPATIBLE SCRIPT
158
156
130

FIG. 4

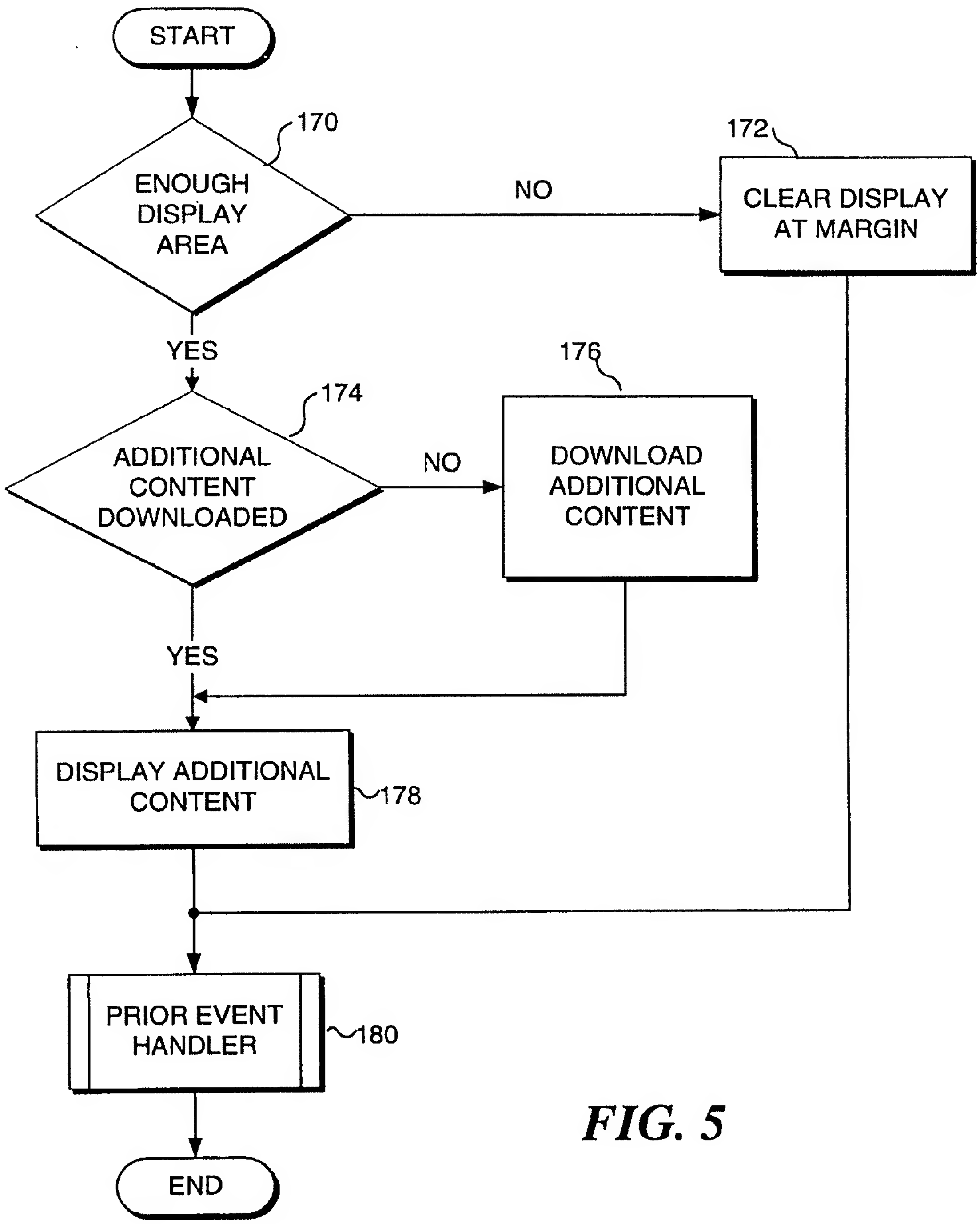

START
170
ENOUGH DISPLAY AREA
NO
172
CLEAR DISPLAY AT MARGIN
YES
176
174
ADDITIONAL CONTENT DOWNLOADED
NO
DOWNLOAD ADDITIONAL CONTENT
YES
DISPLAY ADDITIONAL CONTENT
178
PRIOR EVENT HANDLER
180
END

FIG. 5

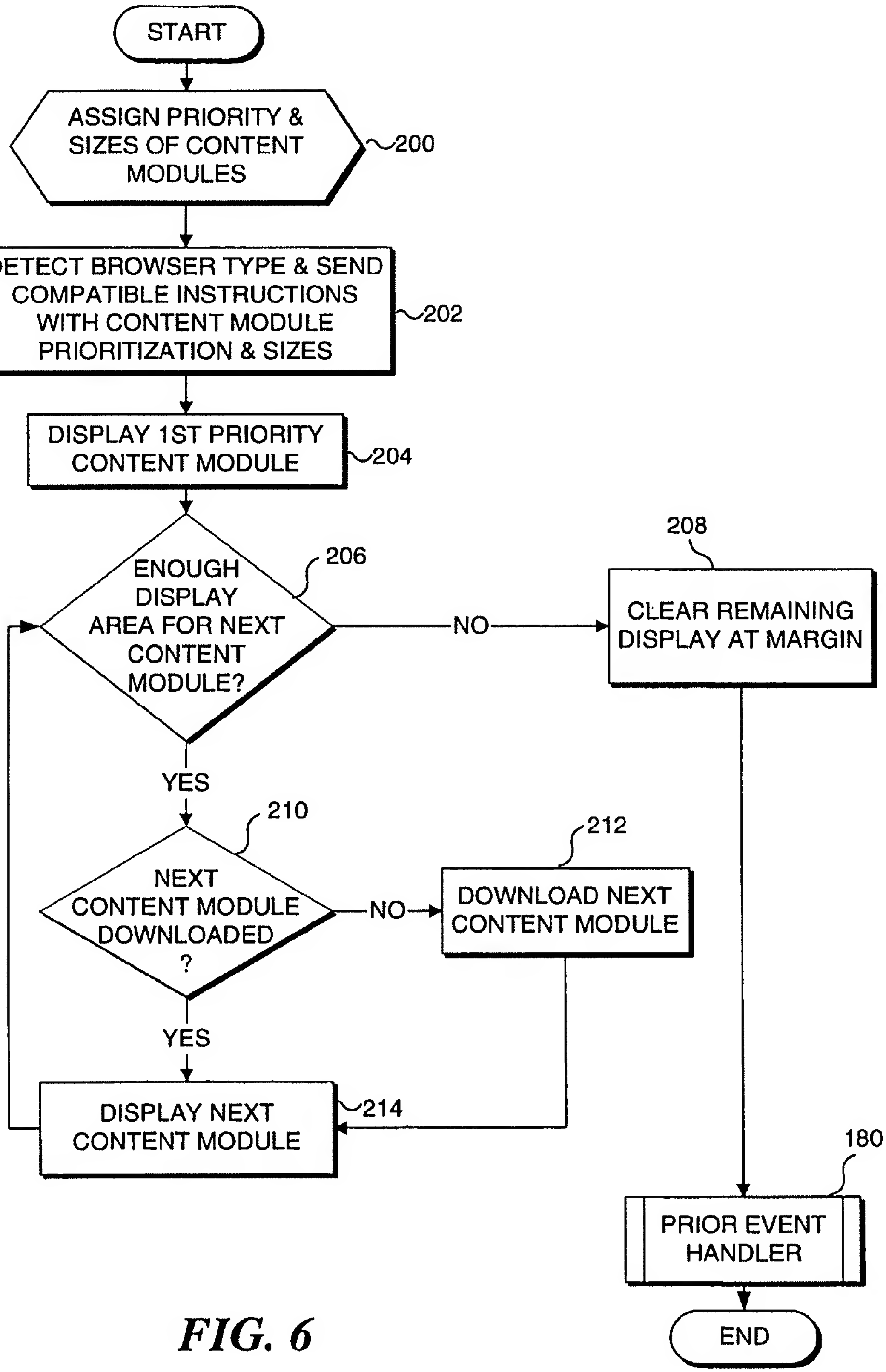

START
ASSIGN PRIORITY & SIZES OF CONTENT MODULES
200
DETECT BROWSER TYPE & SEND COMPATIBLE INSTRUCTIONS WITH CONTENT MODULE PRIORITIZATION & SIZES
202
DISPLAY 1ST PRIORITY CONTENT MODULE
204
ENOUGH DISPLAY AREA FOR NEXT CONTENT MODULE?
206
NO
208
CLEAR REMAINING DISPLAY AT MARGIN
YES
210
NEXT CONTENT MODULE DOWNLOADED ?
NO
212
DOWNLOAD NEXT CONTENT MODULE
YES
DISPLAY NEXT CONTENT MODULE
214
180
PRIOR EVENT HANDLER
END

FIG. 6

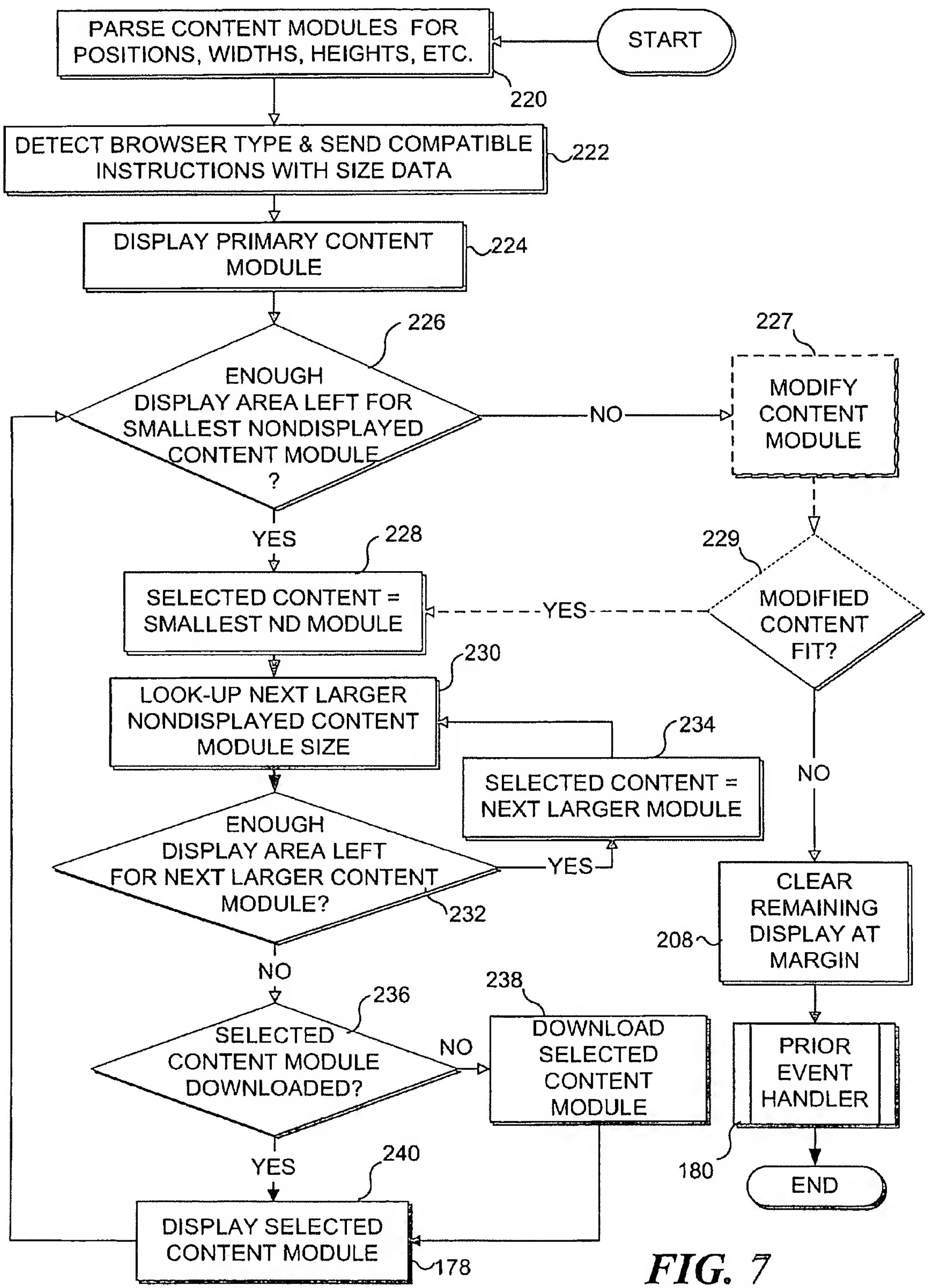

START
PARSE CONTENT MODULES FOR POSITIONS, WIDTHS, HEIGHTS, ETC.
220
DETECT BROWSER TYPE & SEND COMPATIBLE INSTRUCTIONS WITH SIZE DATA
222
DISPLAY PRIMARY CONTENT MODULE
224
226
ENOUGH DISPLAY AREA LEFT FOR SMALLEST NONDISPLAYED CONTENT MODULE ?
NO
227
MODIFY CONTENT MODULE
YES
228
SELECTED CONTENT = SMALLEST ND MODULE
229
MODIFIED CONTENT FIT?
YES
230
LOOK-UP NEXT LARGER NONDISPLAYED CONTENT MODULE SIZE
234
SELECTED CONTENT = NEXT LARGER MODULE
NO
ENOUGH DISPLAY AREA LEFT FOR NEXT LARGER CONTENT MODULE?
YES
232
CLEAR REMAINING DISPLAY AT MARGIN
208
NO
236
238
SELECTED CONTENT MODULE DOWNLOADED?
NO
DOWNLOAD SELECTED CONTENT MODULE
PRIOR EVENT HANDLER
YES
240
180
END
DISPLAY SELECTED CONTENT MODULE
178

FIG. 7

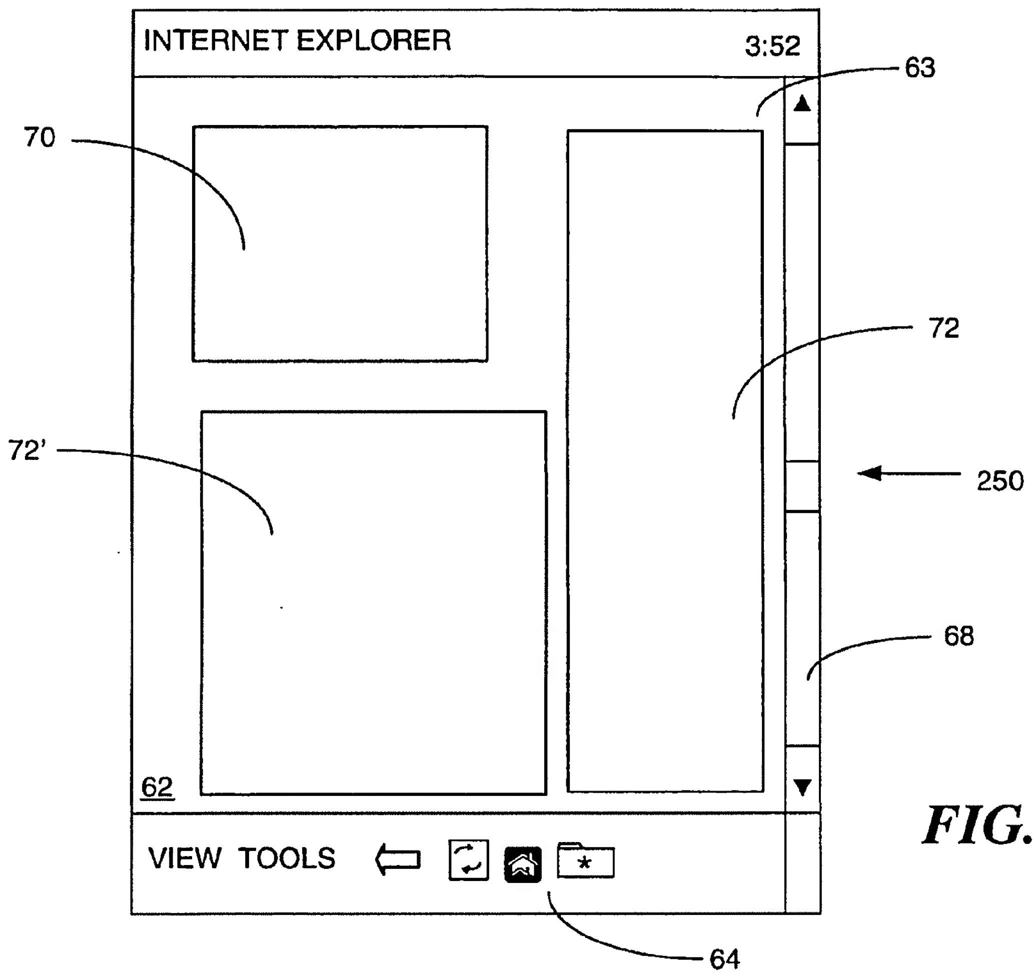

INTERNET EXPLORER
3:52
63
70
72
72'
250
68
62
VIEW TOOLS
64

FIG. 8A

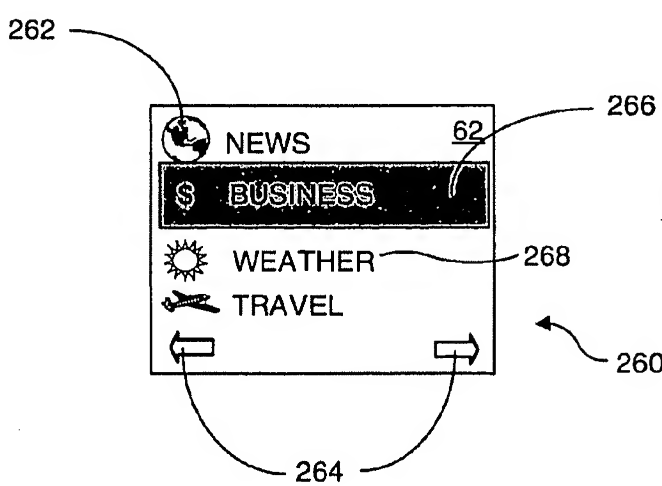

262
266
NEWS
62
$ BUSINESS
WEATHER
268
TRAVEL
260
264

FIG. 8B

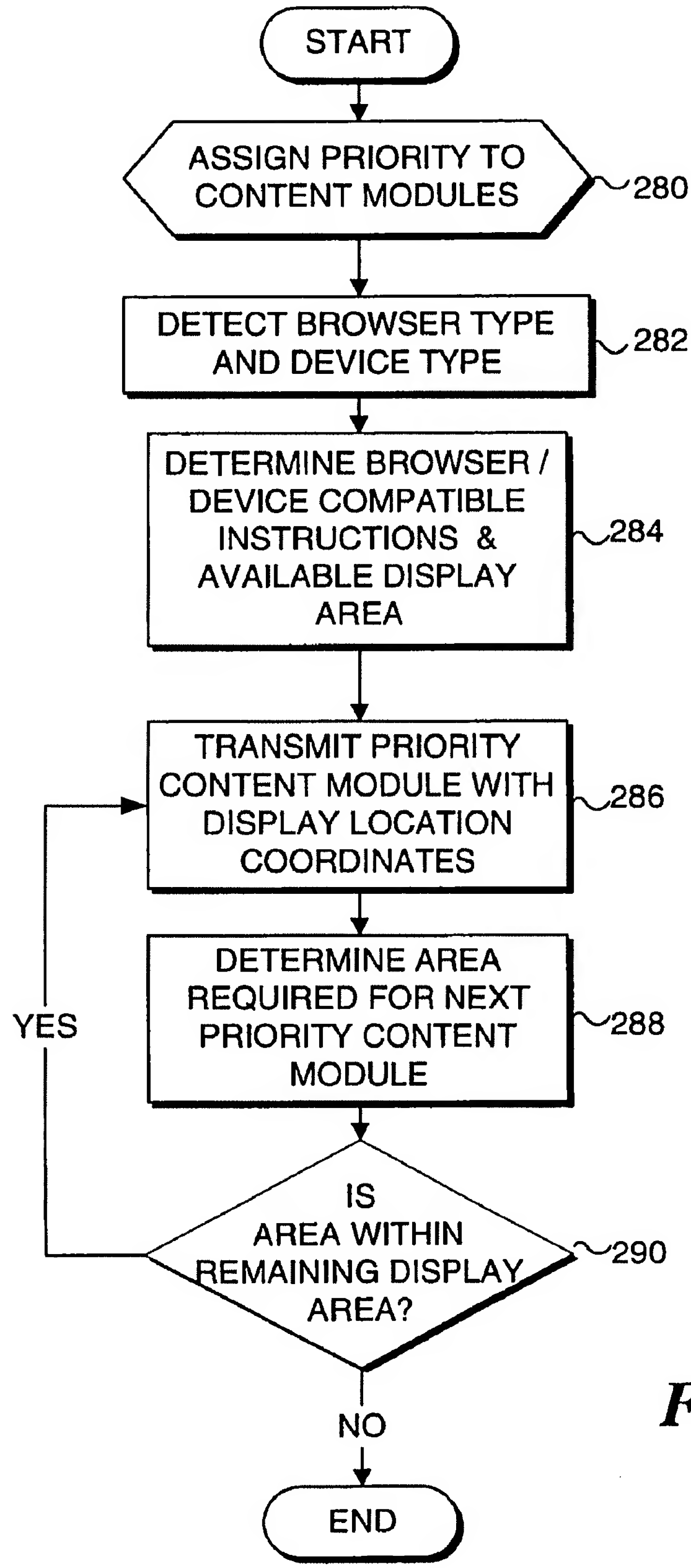

START
ASSIGN PRIORITY TO CONTENT MODULES
280
DETECT BROWSER TYPE AND DEVICE TYPE
282
DETERMINE BROWSER / DEVICE COMPATIBLE INSTRUCTIONS & AVAILABLE DISPLAY AREA
284
TRANSMIT PRIORITY CONTENT MODULE WITH DISPLAY LOCATION COORDINATES
286
DETERMINE AREA REQUIRED FOR NEXT PRIORITY CONTENT MODULE
288
YES
IS AREA WITHIN REMAINING DISPLAY AREA?
290
NO
END

FIG. 9

SELECTIVE DISPLAY OF CONTENT

FIELD OF THE INVENTION

The present invention generally relates to a method and system for controlling retrieval and display of content on a display device, and more specifically, to selective retrieval and display of additional content within a limited browser window display area, without requiring scrolling.

BACKGROUND OF THE INVENTION

World Wide Web (WWW) documents, or Web pages, are widely used for distributing information to a variety of client devices, including personal computers, Web-compatible television set top boxes, personal data assistants (PDAs), wireless telephones, and other Internet connected devices. However, the amount, and quality of content that can be displayed in a Web page without scrolling depends on the size of the device's browser window, which is limited by the available display resolution. When only a small display is available, some of the content may be hidden until the user scrolls the display to disclose the content within the browser window.

Clearly, scrolling to display hidden Web page content is not as convenient as displaying all of the content within a browser window. In contrast, when a large display area is available, the content often does not completely fill the available area, leaving blank space that could be employed to display additional content or information. This blank space within a browser window of a larger display area, which is not used for displaying the primary content of a Web page, would be especially useful for displaying advertising or other non-essential content.

On most personal computers, the minimum display resolution is 640×480 pixels, but it is generally assumed that most users will set their computer display for a resolution of at least 800×600 pixels. Although the maximum display resolution of the video adapters and monitors used on many modern personal computers are substantially greater than this, Web content developers typically design Web pages to be fully displayable without horizontal scrolling in an area of 800×600 pixels. The additional area within the browser window on systems set to a resolution greater than 800×600 pixels (when using the full display area) is thus typically unused on modern personal computer displays. Of course, a user can selectively set the size of a browser window on a display running at a higher resolution so that the browser window uses only a portion of the available display area. For example, the browser window can be selectively adjusted by a user for a width of 800 pixels on a display set for a resolution of 1024×768 pixels.

Conversely, on devices having display areas that are smaller than 800×600 pixels, such as PDAs or Internet enabled cell phones, a user will be required to scroll both horizontally and vertically to view all of a conventional Web page width. Clearly, it would be preferable to supply a Web page to a display of an Internet connected device that is appropriate for the currently available browser window area, so that the content can be viewed without scrolling in at least one of the horizontal and vertical directions.

Unfortunately, server-side documents and applications have no way of directly detecting the amount of display area available in the browser window on any given client device at any particular time. There are only a few ways of adjusting the amount of display area available on any given client device, running any given browser program, at any given time. For example, it might be possible to force a new browser window to open, and specify the browser window size to accommodate the Web page being requested. However, in this case, it would be necessary to make an initial assumption about the display area size available on the client device and predetermine the window size of the Web browser program. In any case, this solution would likely not be acceptable to users, because it would require the requested Web page to change the browser window size, which most users would likely find objectionable. The more common solution to this problem is for the server to simply download a requested Web page in the size required to hold additional content. However, scroll bars are then required to display the additional content, if the browser window on the client device is not sufficiently large.

In some instances, pre-designed content is split into layers or frames that draw from multiple source files. Each layer is set to be either displayed or hidden. However, there is no known use of layers or frames to selectively download and/or display portions of content based on fitting the content within the available display area to limit scrolling to at most one direction. Layering was designed to allow portions of content to overlap each other or appear in a sequence to provide an animation effect. Layering was not designed to provide non-overlapping selective display of content modules based on the size of the display area, because scrolling is relied on for viewing any content that is beyond the margins of the display area. Note also that layering is only applicable to controlling a browser program display, usually on a client device. Layering is not applicable to controlling an active server page, or other server program that does not relate to displaying content. Such server programs usually relate to non-visual data processing and communicating content from the server. Alternatively, frames enable a display to be split into sections, but each frame is provided with its own scrolling capability. Also, any additional scroll bars required in a frame take up more display area. Thus, frames do not enhance efficient use of the display or limit scrolling to at most one direction.

For many smaller devices with fixed display areas, servers detect the requesting device and provide separate specialized content that is formatted for the small display area. The content may be an HDML, WML, or other document format optimized for the size of the display of the requesting device. Often a separate single page of content is pre-defined to fit the display of the numerous possible requesting devices, which requires that multiple documents formatted for each display size be provided.

Alternatively, some systems use proxy servers with content manipulators to pre-process existing documents to reduce, convert and/or compress the content before sending it to the small device. Such systems include Puma Technoloy, Inc.'s PROXYWARE™, International Business Machines, Inc.'s transcoding proxies, and Spyglass, Inc.'s SPYGLASS PRISM™. The approach used by these systems is effected on proxy servers between the Web server containing the requested document and the requesting client device and provides for translating existing documents to a format suitable for the requesting device having a small display. However, no provision is made in these systems for the original designer of the content to modularize or prioritize the content, to control the portions of the content that are displayed based upon the available display or browser window area.

A further alternative would be to scale some content to fit within an available display area on a client device. However, this solution may cause content designed for a small display

to be enlarged to fit within a large display area so much as to present a poor impression. Alternatively, content originally designed for a high resolution display may be reduced so much to fit in a relatively small display as to be unreadable or unusable. Also, graphical advertisements, such as banner advertisements, are not typically dynamically resizable, and their effectiveness will likely be substantially reduced if they are scaled. A better solution would be to determine the available size of the browser window or the display (if all of the display is available) and send only the highest priority portion of the content that will fit the available display area without requiring scrolling in more than one direction, or more preferably, without requiring scrolling in other than a vertical direction, or most preferably, without requiring any scrolling.

SUMMARY OF THE INVENTION

The present invention addresses the problems identified above by selectively displaying portions of content to fit an available display area, instead of leaving some display area unused or requiring a user to selectively view all the content by scrolling. A first aspect of the present invention is directed to a method for selectively displaying additional content on a display device within a limited browser window display area. The method includes the steps of detecting the size of an available display area, and determining whether the additional content and primary content can both be fully displayed in the available display area without requiring scrolling in more than one direction. If so, both the additional content and primary content are displayed. Otherwise, only the primary content is displayed in the display area.

The available display area includes the portion of a browser window that is available for displaying content (i.e., not occupied by tool bars, status bars, or other graphical user interface elements of a browser program). The method includes the step of detecting properties of the browser program, such as the specific browser program and version, so that appropriate instructions can be provided to the browser program that are compatible with it and will enable detection of the dimensions of the display area.

The step of determining whether both primary and additional content can be fully displayed in the available display area in this manner occurs when primary content is initially loaded by the browser program, whenever the browser window is re-sized, or upon the occurrence of another predefined event. The method can be implemented as an event handler that takes advantage of browser event triggers and will then store a pointer to any previously defined event handler used by the browser program that is replaced or supplemented by the event handler of the present invention. If appropriate, such a previously defined event handler is then executed after the selective display of the additional content, or if only the primary content is displayed.

Preferably, the method determines if at least one dimension (e.g., a width or a height) of the available display area is at least equal to a predefined value, so that the display area is sufficient to display the additional content without scrolling in more than one direction. The method can also iteratively determine whether still more content can be fully displayed in the available display area without requiring scrolling along with the primary content and any previously added content. Preferably, scrolling should not be required in a direction extending across the primary content and all of the additional content in the available display area.

The additional content is retrieved only when it can be displayed and is then retained in local storage. If the additional content was previously retrieved, it is obtained from the local storage and displayed along with the primary content, when the display area becomes sufficient to meet the requirements regarding scrolling in no more than one direction. Also, if the browser window is reduced so that the additional content cannot be displayed in the available display area, as noted above, the additional content is removed from the display, but remains available in the local storage if again needed, should the display area again become sufficient to include the additional content.

Another aspect of the invention is directed to a method for selectively displaying a selected portion of content (without a distinction between primary and additional content). An appropriate portion of the content is selectively displayed, based upon the available display area. In one preferred embodiment, portions of the content are assigned a predefined priority, to determine the portions that are displayed, as a function of the available display area. Alternatively, the content is altered to fit within the available display area by selecting those portions whose combined sizes make maximum use of the available display area.

Yet another aspect of the invention is directed to a method for selecting portions of content document based on a known available display area, before conveying the selected portions to a browser program. This method is especially useful for pre-selecting, communicating and displaying appropriate portions from within a page to fit small fixed-displays used for browsing, such as on some PDAs and cellular phones.

Another aspect of the invention is directed to a computer-readable medium having computer-executable instructions for performing the method disclosed above. A further aspect of the present invention is directed to a system that includes elements that carry out functions generally consistent with the steps of the method discussed above.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic block diagram of an exemplary personal computer (PC) system suitable for implementing the present invention;

FIG. 2A is a representation of a browser window displaying only a primary content of a Web page;

FIG. 2B is a representation of a browser window displaying an additional content to the right of the primary content;

FIG. 2C is a representation of a browser window displaying an additional content displayed to the left of the primary content;

FIG. 2D is a representation of a browser window displaying a plurality of additional content selections, in two columns to the right of the primary content;

FIG. 2E is a representation of a prior art browser window in which the size of the display area is such that it can only display a primary content of a Web page and which employs scroll bars to display any additional content;

FIG. 3 is a flow diagram illustrating the logic used by the present invention to provide instructions that are compatible with a requesting browser to selectively display additional content in a Web page based on the available display area;

FIG. 4 is a block diagram illustrating components used by a preferred embodiment of the present invention to provide

instructions that are compatible with a requesting browser to selectively display additional content in a Web page based on the available display area;

FIG. 5 is a flow diagram illustrating the logic used by the present invention to selectively display additional content in a Web page based on the available display area;

FIG. 6 is a flow diagram illustrating the logic used by the present invention to selectively display multiple content modules in a Web page based on the available display area and a prioritization assigned to the content modules;

FIG. 7 is a flow diagram illustrating the logic used by the present invention to selectively display multiple content modules in a Web page based on the available display area and the size of the content modules;

FIG. 8A is a representation of a browser window on a typical PDA with a plurality of content modules displayed;

FIG. 8B is a representation of a browser window on a small cellular telephone with a plurality of content modules displayed; and

FIG. 9 is a flow diagram illustrating the logic used by the present invention to pre-select and display multiple content modules of a Web page based on a known display area and a priority of the content modules.

DETAILED DESCRIPTION OF THE INVENTION

Exemplary Operating Environment

FIG. 1 and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the present invention may be implemented, both in regard to a server that stores and provides Web pages and a client that requests the Web pages and displays them to a user. Although not required, the present invention will be described in the general context of computer executable instructions, such as program modules that are executed by a personal computer. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that this invention may be practiced with other computer system configurations, particularly in regard to a client device for displaying a Web page, including hand held devices, pocket personal computing devices, digital cell phones adapted to connect to a network and other microprocessor based, or programmable consumer electronic devices, multiprocessor systems, network personal computers, minicomputers, mainframe computers, and the like. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

With reference to FIG. 1, an exemplary system for implementing the present invention includes a general purpose computing device in the form of a conventional personal computer 20, provided with a processing unit 21, a system memory 22, and a system bus 23. The system bus couples various system components including the system memory to processing unit 21 and may be any of several types of bus structures, including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory includes read only memory (ROM) 24 and random access memory (RAM) 25. A basic input/output system 26 (BIOS), containing the basic routines that helps to transfer information between elements within the personal computer 20, such as during start up, is stored in ROM 24. The personal computer 20 further includes a hard disk drive 27 for reading from and writing to a hard disk, not shown, a magnetic disk drive 28 for reading from or writing to a removable magnetic disk 29, and an optical disk drive 30 for reading from or writing to a removable optical disk 31, such as a CDROM or other optical media. Hard disk drive 27, magnetic disk drive 28, and optical disk drive 30 are connected to system bus 23 by a hard disk drive interface 32, a magnetic disk drive interface 33, and an optical drive interface 34, respectively. The drives and their associated computer readable media provide nonvolatile storage of computer readable machine instructions, data structures, program modules and other data for personal computer 20. Although the exemplary environment described herein employs a hard disk, removable magnetic disk 29, and removable optical disk 31, it will be appreciated by those skilled in the art that other types of computer readable media, which can store data that is accessible by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, random access memories (RAMs), read only memories (ROMs), and the like, may also be used in the exemplary operating environment.

A number of program modules may be stored on the hard disk, magnetic disk 29, optical disk 31, ROM 24 or RAM 25, including an operating system 35, one or more application programs 36 (such as a browser program), other program modules 37, and program data 38. A user may enter commands and information into personal computer 20 through input devices such as a keyboard 40 and a pointing device 42. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to processing unit 21 through an input/output (I/O) interface 46 that is coupled to the system bus. The term I/O interface is intended to encompass each interface specifically used for a serial port, a parallel port, a game port, a keyboard port, and/or a universal serial bus (USB). A monitor 47 or other type of display device is also connected to system bus 23 via an appropriate interface, such as a video adapter 48, and is usable to display Web pages, and/or other information. In addition to the monitor, personal computers are often coupled to other peripheral output devices (not shown), such as speakers (through a sound card or other audio interface—not shown) and printers.

Personal computer 20 may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer 49. Remote computer 49 may be another personal computer, a server (which is typically generally configured much like personal computer 20), a router, a network personal computer, a peer device, satellite or other common network node, and typically includes many or all of the elements described above in connection with personal computer 20, although only an external memory storage device 50 has been illustrated in FIG. 1. The logical connections depicted in FIG. 1 include a local area network (LAN) 51 and a wide area network (WAN) 52. Such networking environments are common in offices, enterprise wide computer networks, intranets and the Internet.

When used in a LAN networking environment, personal computer 20 is connected to LAN 51 through a network interface or adapter 53. When used in a WAN networking environment, personal computer 20 typically includes a modem 54, or other means for establishing communications

over WAN **52**, such as the Internet. Modem **54**, which may be internal or external, is connected to the system bus **23**, or coupled to the bus via I/O device interface **46**, i.e., through a serial port. In a networked environment, program modules depicted relative to personal computer **20**, or portions thereof, may be stored in the remote memory storage device. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers may be used, such as wireless communication and wide band network links.

Exemplary Implementation of the Present Invention

The following describes an exemplary implementation in a first preferred embodiment of the present invention corresponding to its use in displaying additional content generally to the right of the primary content in the display area of a browser window on a personal computer monitor. Additionally, the following implementation is described in the context of a browser program displaying Dynamic Hyper-Text Markup Language (DHTML) Web page documents on a client computer in communication with a server via the Internet. However, as suggested earlier, this example is not meant to be limiting, as it will be understood by those skilled in the art that the concepts and method disclosed below are applicable to any type of device for displaying content, including network appliances, PDAs, cellular phones, and the like. It is also contemplated that the concepts and method disclosed below are applicable to any type of documents based on a markup language, including HTML, standard generalized markup language (SGML), extensible markup language (XML), hand-held device markup language (HDML), wireless markup language (WML), and other documents of the like. It will further be understood that the concepts and method disclosed below are applicable to any type of compiled or interpreted component, including Microsoft Corporation's WINDOWS™ script components, component object model components, document object model components, Microsoft Corporation's ACTIVEX™ controls and Active Server Pages, common gateway interface applications, Sun Microsystems, Inc.'s JAVA™ applets, JAVA™ servlets, and the like. Also, the concepts and method disclosed below are applicable to any type of compiled or interpreted computer code language, including C++, Sun Microsystems, Inc.'s JAVA™, JavaScript, VBScript, ECMAScript, WMLScript, Perl, and the like.

Generally, this embodiment of the present invention selectively adds extra content to make use of otherwise unused available space in a browser window display area, where the available space is beyond the limits of a primary content in at least one direction. But the extra content is displayed only if the available area in the window (or display) is sufficiently large to accommodate both the primary and the additional content without requiring the user to scroll in more than one direction. Preferably, any scrolling should be in a direction that does not extend across the primary and extra content and will typically be only in the vertical direction, since in many cases, the extra content will be selectively added to one side of the primary content. Simply adding additional content to an existing Web page without regard to the available display area in a browser window, as commonly done in the prior art, is an undesirable alternative to the present invention, because a user may be required to scroll both vertically and horizontally to view all of the content, i.e., both the primary content and the additional content. As noted above in the Background of the Invention, it is undesirable for a user to scroll both vertically and horizontally to access all of a Web page—primary and added content.

FIG. **2A** illustrates a generally conventional browser window **60** with a content display area **62**, a menu and toolbar area **64**, a status bar **66**, and a scroll bar **68**. Shown within content display area **62** is a primary content **70**. Primary content **70** may comprise text, video, or graphics and may include sounds, or other content of the various types typically contained in Web pages. Web page documents are typically requested by a user from a remote server (not shown) and are downloaded from the remote server into the browser window over the Internet, and/or other network, such as an intranet. Most Web page documents are designed to be displayed within a predefined display area, such as 800×600 pixels. However, the browser window may be opened and maximized (or adjusted to a larger size than the area which the primary content was designed to occupy) on a display or monitor having a substantially greater resolution, e.g., 1024×768 pixels. When primary content **70** is displayed within this larger area of browser window **60**, an additional display area **63** is available within content display area **62**, but is not used for the primary content. In most cases, additional display area **63** is thus "wasted." Conversely, if the primary content is designed for a display area larger than display area **62**, a user must scroll the primary content within display area **62** using scrollbar **68** (and/or its horizontal equivalent—not shown), to view the remainder of the primary content.

To enhance the user experience when viewing a Web page, it is desirable to reduce or eliminate the need to scroll to view the entire content that can be displayed. The user should not be required to scroll in more than one direction (preferably, only vertically) to fully view a Web page. On the other hand, it is often desirable for commercial reasons, to maximize the amount of content displayed in content display area **62**, particularly if the additional content added to the Web page includes advertising that can increase revenues for a Web site.

To balance these competing interests, a preferred embodiment of the present invention selectively displays added content **72** in an unused portion **63** of content display area **62**, as shown in FIG. 2B. In the preferred embodiment of the present invention shown in FIG. 2B, unused portion **63** of content display area **62** is disposed to the right of primary content **70**, and added content **72** will likely (although not necessarily) include advertising that is not generally related to the primary content. However, different preferred embodiments of the present invention can alternatively display added content **72** in other portions of the display area **62**, such as to the left of the primary content **70**, as shown in FIG. 2C. Furthermore, the added content may be directed to information that is related to the primary content.

As additionally illustrated by FIG. 2D, multiple additional content can be selectively displayed in the unused portion of available content display area **62**. Moreover, this embodiment of the present invention selectively displays both primary content **70** and additional content **72** in content display area **62** only when the primary content and the one or more modules of additional content can be displayed without requiring scrolling in more than one direction. Thus, in FIG. 2D, added content **72** and added content **72'** would be displayed along with primary content **70** only if there is sufficient display area to the side of primary content **70** so that all three modules can be displayed across the width of the screen without scrolling both vertically and horizontally. In this example, scrolling is required only in the vertical

direction to enable all of the contents of these three modules to be fully displayed, because the primary content extends below the bottom of the available content display area.

As a further alternative, the added content **72** could be displayed to the left of primary content **70**, and added content **72'** displayed to the right of the primary content **70**. As a still further alternative, either or both of the added content modules could be displayed above or below the primary content **70**. While less desirable, scrolling would still only be necessary in the vertical direction to display all of the primary and added content. The invention can also be practiced to selectively display additional content only if scrolling will not be required in either direction.

The following example should ensure that the differences between the present invention and the conventional approach for handling content greater than an available display or browsing window area is clear. In the conventional approach, scrolling in both the vertical and horizontal directions may be required to display all content if a browser window **60** is limited or resized to such dimensions that content display area **62** is insufficient to display either or both the primary and additional content in both directions. FIG. **2E** illustrates a prior art browser window **60'** that is sized so that only primary content **70** can be fully displayed across the width of the content display area. Phantom lines indicate where a portion of additional content **72** would appear if it were added without employing the present invention, and it should be understood, that unless the user scrolls to the right, the remainder of the additional content that is currently hidden will not be displayed. Employing the present invention, the browser program would not even load additional content **72**, because to do so would require that the user scroll both vertically and horizontally to view the entire content. By detecting that insufficient display area dimensions exist during an initial load of the primary content of a Web page, the present invention eliminates the unnecessary communication and retrieval of that additional content, and avoids the undesired scrolling that would be required to fully view additional content **72**.

Clearly, a user may reduce the size of a browser window after additional content **72** has already been fully displayed. The size of the browser window is typically reduced by pressing a restore/maximize button **74**, by dragging a browser window dynamic resize control **76**, or by dragging an edge of browser window **60**. In response to these actions, the browser program would normally add horizontal and/or vertical scroll bars **68** (if not already provided) as needed to enable the user to view all of the content in each direction in which the full content is no longer displayed. Browser programs are not currently designed to remove any content from the display in an attempt to reduce or eliminate the need for scrolling. In fact, they are specifically designed to automatically provide scrolling, because they currently treat all content equally. To provide greater control over the display of content, the present invention responds to actions that reduce the size of the browsing window below that required to display all of the content without scrolling, by removing additional content **72** from the display, so that at most, primary content **70** must be scrolled to view all of it.

As indicated above, removing additional content **72** to reduce or eliminate scrolling of the browser window in more than one direction improves a user's experience. Also, the additional content, once downloaded to be displayed, is preferably retained in memory to enable the additional content to quickly be re-displayed if the browser window is subsequently sufficiently enlarged to fully display the primary and additional content without scrolling in more than one direction. This feature eliminates the need to again load the additional content from a remote permanent storage, which would likely be on a server.

Preferably, the present invention is automatically initiated when a Web page is initially loaded, and in response to a resizing of the browser window for any reason. These events are triggers to which the browser program will typically already respond, and can be utilized to initiate browser compatible instructions that are different than those normally executed by the browser program. One embodiment of the present invention includes an event handler that preemptively extends any corresponding previously defined event handlers. A Web page designer simply includes a call to the invention, which automatically responds to each relevant event trigger, such as the initial loading of the Web page or the resizing of the browser window.

The specific event handler instructions used to implement the present invention depend upon the type and/or version of browser program used to display the Web page content. FIG. **3** illustrates how specific browser-compatible instructions are provided to the browser program. In this preferred embodiment, a browser program executing on a personal computer connected to the Internet communicates via Transmission Control Protocol/Internet Protocol (TCP/IP) with a Web server. When a user of the browser program requests content from the server by selecting or entering a uniform resource locator (URL) for a Web page, the browser program creates a request header, as indicated in a block **100** of FIG. **3**. A request header is typically a Hypertext Transfer Protocol (HTTP) string that identifies the client device and its IP address on the network. The request header also identifies certain properties of the requesting browser, such as the type of browser program and its version. The type of browser may be Microsoft Corporation's INTERNET EXPLORER™, Netscape Corporation's NAVIGATOR™, or other browser that operates on one of the various client devices described above. The portion of the header that includes the browser type is often referred to as the "user agent string." At a block **102**, the browser program communicates the header, along with the rest of the content request to a control object in software executed on a Web server.

The request is typically for a Web page document containing the primary content **70** at a Uniform Resource Locator (URL) address. Preferably, the requested Web page is an active server page that contains instructions to execute a control object on the Web server that will provide the browser compatible instructions. Another alternative would be to intercept the request at some intermediate point prior to retrieving the requested Web page and pre-process the request to identify and obtain browser compatible instructions. Yet another alternative would be to intercept the request and pre-determine whether and which additional content **72** (if any) should be returned to the browser program along with primary content **70**.

In the illustrated preferred embodiment, the requested Web page calls a control object on the server that reads and parses the request header to obtain the browser type and version information as shown at a block **104**. The parsed browser type and version information is compared with known browser types (and versions—although not specifically shown) in decision blocks **106**, **108**, and **110**, etc. to determine the instructions that will be compatible with the browser program that sent the request. At one of blocks **112**, **114**, **116**, etc. the compatible instructions for the browser program (and version) that was determined are appended to the requested primary content Web page file. In a preferred

embodiment, these instructions are script code, such as JavaScript, that are appended to the Web page document containing the requested primary content **70**. At a block **1118**, the Web server control object then sends the modified Web page to the browser program on the client device over the network.

When the modified Web page is received by the client at a block **120**, the browser program first executes that portion of the new instructions that overrides or supercedes prior corresponding event handler instructions, if any, which were included in the original Web page for responding to a trigger event, such as an OnLoad event or a Resize event. Specifically, the new instructions first rename any event handlers previously assigned to an OnLoad, Resize or other predetermined event trigger. This step preserves the prior event handlers for later execution. Then, the new instructions assign the new event handler to these event triggers. At a block **122**, the browser program on the client device then executes the new instructions comprising the superceding event handler to selectively display additional content if the display area is sufficient to support both the primary and additional contents without requiring scrolling in more than one direction.

FIG. **4** illustrates aspects of this preferred embodiment of the present invention in regard to the control objects executed on the Web server. As indicated above, a requested Web page document **130** preferably contains both primary content **70** and script code. However, it may contain only code that refers to another primary document file, or files that contain primary content **70**. Preferably, the requested Web page document does not include additional content **72**. Instead, additional content **72** is preferably contained in a separate document file. Thus, requested Web page **130** is preferably an active server page (ASP), Common Gateway Interface (CGI) application, or other functional document. Such a document will contain JavaScript, Perl, or other executable code embedded within it. Those skilled in the art will recognize that requested page **130** is not limited only to Internet Web pages, but may be any type of file or other resource that can be requested by a client device for display.

When a browser program executed on a client device requests Web page **130** from the Web server, the script code within the requested page **130** makes a function call **132** to a selective display control object **134**. Selective display control object **134** contains a control function or control method **136** that controls the Web server side operations. Via a data retrieval operation **138**, control method **136** retrieves client request header information **140** and communicates the information through a function call **142** to a browser detection sub-object **144**. Browser detection sub-object **144** implements a browser detection method **146** that parses and detects the browser properties from client request header information **140**. The browser detection method then relays the browser type and version via a function call return **148** back to control method **136**. Control method **136** uses the browser type and version to determine the compatible browser instructions that should be appended to requested Web page **130**. Control method **136** makes an appropriate function call **150** or **150'**, respectively directed to MS Method **152** or Netscape Method **154** (or other), to the appropriate method to retrieve or generate instructions to selectively display additional content in the indicated browser program. The appropriately called method retrieves or generates code compatible with the browser program indicated to be running on the client device. The compatible code is communicated via a function return **156** and added to requested page **130** as browser compatible script **158**. The modified page is then communicated back to the browser on the client device over the Internet or other network that connects the server with the client device.

As described above, the instructions included in the modified Web page override prior event handlers but preserves a pointer to the prior event handlers for later execution, as appropriate. The core selective display operation is executed as a superceding event handler by the client browser as illustrated in FIG. **5**. As also noted above, this event handler embodiment is triggered by an OnLoad, Resize, or other pre-selected event.

Upon the occurrence of such an event, a decision block **170** in FIG. **5** provides for determining whether enough display area is available in the browser window to display both primary and additional content without scrolling in more than one direction. Browser-compatible instructions call on Document Object Model components of the browser program to detect the dimensions. For example, JavaScript instructions compatible with Microsoft's Internet Explorer browser call a "clientWidth" property of the Document object to determine the width in pixels of content display area **62** in the browser window.

If the size of the content display area is insufficient to display the added content and the primary content without requiring scrolling in more than one direction, remaining display portion **63** around the primary content is cleared in a block **172**, and by following the pointer to the prior event handlers, they are executed, as provided in a block **180**. Thus, in an initial OnLoad case, the new event handler instructs the browser program to forego even downloading additional content **72** if the display is not sized sufficiently to accommodate (i.e., view all of) both the primary content and additional content without scrolling in more than one direction. This feature eliminate the unnecessary downloading of additional content **72** from the Web server. Alternatively, in response to an OnResize event, clearing the remaining display portion **63** effectively removes additional content **72** from the display when content display area **62** is reduced to a size insufficient to fully display both primary and additional content without scrolling in more than one direction. Thus, the same instructions are effective for multiple types of event triggers.

Conversely, if sufficient content display area **62** is available, a decision block **174** provides that the event handler determines whether the additional content was previously downloaded, which may have occurred in order to display the additional content before the browser window was reduced in size. If the additional content was not previously downloaded, then a request is made to the server to download additional content **72** at a block **176**. Waiting until this point to download the additional content avoids unnecessary time in downloading the additional content if it will not be displayed. However, once the additional content has been downloaded and displayed, saving the additional content in a cache in memory on the client device avoids the time required to download the additional content again. Once the additional content is available at the client device, at a block **178**, the browser displays the additional content along with the primary content.

A second preferred embodiment of the present invention employs layer or frame concept when displaying content as a function of the available browser window/display size. This embodiment first determines whether enough display area is available to display the additional content without requiring scrolling in more than one direction, and if so, generates or otherwise provides appropriate browser compatible instructions for displaying a layer that includes the

additional content. The additional content source file is communicated to the browser program along with these instructions. In all other respects, this second embodiment is identical to the first disclosed above. Those skilled in the art will recognize that the approach used in this second embodiment can be iterated for selectively displaying multiple modules of content so long as sufficient content display area **62** remains to display each successive module. However, if the display area is only sufficient for the primary content, then no browser compatible instructions are transmitted to the client device or executed for displaying a layer of additional content. Also, no source file of the additional content layer is communicated to the browser program. Once the additional content is displayed in either the first or the second embodiment, the pointer to the corresponding prior event handlers, if any, enables them to be executed at step **180** in FIG. **5**.

FIG. **6** illustrates logic for another iterative embodiment of the invention. The iterations in this case are based on a priority assigned to content modules. In a block **200**, a priority is assigned and the size of each content module is defined. The size is preferably defined in pixels. As in the previous embodiments, the browser type and version are determined from the header of a request received from the client device in a block **202**, and browser compatible instructions are prepared for communication to the browser program being executed on the client device. However, in this embodiment, the content module priorities and sizes are also communicated to the browser program. In a manner analogous to displaying primary content **70**, this embodiment displays a first (highest) priority content module in a block **204**. In a decision block **206**, the browser compatible instructions determine a remaining display area and compare that remaining area with the size of the next priority content module. If the remaining display area is insufficient to accommodate the next priority content module (i.e., the content module with the next lower priority), then this embodiment clears the remaining display area at the margin of the display (or browser window), as indicated in a block **208**. As in previous embodiments, the pointer to the prior event handlers corresponding to those implemented by the instructions transferred to the browser program, if any, is recalled and the prior event handlers are executed in block **180**, just as in the previous embodiments.

If the determination made in decision block **206** is that sufficient display area is available to accommodate the next lower priority content module, a decision block **210** determines whether the next priority content module has been already downloaded. If not, the next priority content module is downloaded to the browser program in a block **212**. This next priority content module is then displayed in a block **214**. If the next priority content module was already downloaded in the determination made in decision block **210**, it is also displayed as provided in block **214**. The logic then returns to decision block **206** to determine whether any remaining display area can accommodate the next lower priority content module. This iteration continues until the remaining display area is insufficient in size to accommodate the next priority content module.

The logic for another embodiment is illustrated in FIG. **7**. This embodiment maximizes use of the available display area by selecting and displaying content modules that will fill the largest amount of display space available without requiring scrolling at all, or alternatively, in no more than one direction. To do so, this embodiment parses the content modules for their dimensions and/or designated positions in a display or browser window, in a block **220**. This step can be accomplished by reading DIV tags or individual style attributes of a markup language document. This embodiment is especially well-suited for implementations that utilize cascading style sheets and/or other forms of absolute positioning. As before, a block **222** detects the browser type and version and returns corresponding browser compatible instructions along with the parsed size data for the content modules. A block **224** indicates that a primary content module is displayed. An alternative variation of this embodiment displays the largest content module that will fit within the available content display area without scrolling in more than one direction (or optionally, without scrolling at all).

A decision block **226** determines whether there is enough display area remaining for the smallest currently non-displayed content module to be added. If not, then optionally, the smallest non-displayed content module is modified in an attempt to fit the module to the remaining display area at a block **227**. Modifications include changing one or more dimensions of the content module, scaling the content module, changing text font size within the content module, rotating the content module, providing a moving image of the content within the content module, converting the content to audio or other manipulation of the content module. These manipulations can be accomplished with a variety of methods, including changing individual style attributes within tags, block attributes, or other content attributes. The changes can also be accomplished dynamically with scripting. Once a modification is made, it is determined at optional decision block **229** whether the modified content module will now fit in the remaining display area. If so, then the process can continue attempting to fit more content modules. Otherwise, the remaining display area is again cleared in a block **208**, and the pointer that was saved for any prior event handlers is used to execute the prior event handlers as provided in block **180**. If enough display area remains for display of at least the smallest currently non-displayed content module, then the logic of this embodiment attempts to determine the largest possible remaining content module that can be fit into the remaining display area. Initially, the logic assigns the smallest non-displayed content module as a selected content module in a block **228**. In a block **230**, the logic identifies the size of the next larger currently non-displayed content module. The size of the next larger content module is compared with the remaining display area to determine whether this next larger content module can be inserted into the remaining content display area, in a decision block **232**. If so, a block **234** identifies this next larger content module as the selected content module instead of the previous smaller content module, and the logic loops back to block **230**. The loop that includes block **230**, decision block **232**, and block **234** continues reiteratively, until the largest content modules not currently displayed that will fit in the remaining content display area is identified. Each iteration could also optionally include block **227**, or sub-iterations of block **227**, to modify the content module in further attempts to fit the module to the remaining display area. Correspondingly, an optional decision block **229** can be included to determine whether the modified content module will fit. The step of modifying individual content modules can be incorporated into any of the embodiments to fit the content into the display area or otherwise provide the content (e.g. provide an audible content), subject to the display area restraints. A decision block **236** then determines whether the selected content module has already been downloaded. If not, a block **238** provides for downloading the selected content module. As before, once the browser program has recalled the selected content module from a storage (if it was

previously downloaded and displayed) or newly downloaded the selected content module, then the selected content module is displayed in the remaining content display area in a block **240**. Although the largest possible content module has thus been selected, some additional content display area may still remain in which a smaller content module may be displayed. Thus, the logic returns to decision block **226** to reiterate the process until not even the smallest currently remaining non-displayed content module will fit into the remaining content display area.

As noted above, this embodiment does not rely on knowing the size of a primary content. It need not assume, for example, an 800×600 pixel resolution. Instead, it dynamically determines the size of each content module and dynamically positions the largest currently non-displayed content modules that will fit, in the available content display area.

However, some browser programs, particularly older versions of currently popular browser programs, do not have the ability to dynamically detect the size of an available content display area. In other cases, the browser window size can not be changed and may be matched or limited to the entire physical display area provided on the client device, as will typically be true of reduced-capability browser programs that execute on client devices such as PDAs, cellular telephones, and other similar small, portable client devices. Nevertheless, many of these browser programs will still have the ability to display content in various locations within the content display area, even if the content is limited to a few small icons or only a few lines of text. Thus, some portion of the display area on such client devices may still be unused, or if the present invention is not employed, display of all of the content may require scrolling in more than one direction. For such client devices, selective loading and display of content modules in accord with the present invention can still be accomplished on initial content loading, although no client-side browser window resize-detection handler is required.

FIG. **8**A is a representation of a browser window **250** that might appear on a PDA, running Microsoft Corporation's POCKET INTERNET EXPLORER™ browser program. The browser window includes content display area **62**, with additional available display area **63** remaining after primary content **70** is displayed. Just as explained above in connection with the larger browser windows employed on personal computers, the total display area on this PDA is limited by including tool bar **64** and any scroll bar **68** that is necessary for viewing content beyond what will fit at one time in content display area **62**. However, browser window **250** can not be resized, so its content display area **62** is fixed and known. Nevertheless, a plurality of content modules, such as primary content **70** and additional content modules **72** and **72'**, can be selectively downloaded and displayed, based on the known browser window/display size.

FIG. **8**B is a representation of a browser window **260** on a cellular telephone. Content display area **62** on this client device includes only text **268** and/or icons **262**. Content display area **62** of small client devices like this cellular phone may also have scroll direction indicators **264** controlled by buttons (not shown). Such small client devices also often have an "Enter" button (not shown) to select a highlighted content item **266** on the display. A content item may comprise a URL hyper link to a Web page with additional detail about the content item, such as a list of parameters, information, or other data that can thus be selectively downloaded and displayed. For example, details and data relating to sports news, directions to a business, or other on-line services often must be scrolled into view. However, it will be apparent that selectively downloading and displaying only icons from a content document, without the text, will enable more content items to be displayed, and may also result in unused content display area being available.

Accordingly, yet another preferred embodiment of the present invention facilitates the download and display of selected portions of a content document as a function of content display area **62** in a browser window **260** (or full display area) on a client device. In this embodiment, the content that is downloaded to the client device might be an entire Web page if the client device is a personal computer, or may comprise a selected one or more content modules comprising the Web page if the client device that is detected is a cellular phone or other client device having a very small display.

FIG. **9** illustrates the logic employed in this embodiment to selectively download and display one or more prioritized content modules. A priority is pre-assigned to each content module available for display of a full Web page, in a block **280**. A content module may include only individual display elements, if desired. As in earlier embodiments, the type and version of the browser program executed on the client device are detected in a block **282**, preferably from a user agent string included in a request header transmitted from the client device to a Web server. However, this step also detects the device type, preferably from the header. With this information, browser compatible instructions and the available display area are determined by the Web server control object in a block **284**. As discussed above, the available content display area is determined based upon the known area of the requesting browser type and/or client display device. In a block **286**, a priority content module is communicated to the browser program with associated browser location coordinates and other attributes, if any. In a preferred embodiment of this logic, determination of known available content display area and selection of priority content is done on Web server before any content module is communicated to the requesting browser program running on the client device. This step eliminates the need to dynamically detect the available contact display area via the browser program DOM. A block **288** determines the area for the next priority content module, preferably from the style attributes of that content module. Because the areas of each content module, and the available content display area are known, the remaining content display area can be computed on the Web server to determine whether the next lower priority content module will fit within the remaining display area, as indicated in a block **290**. If so, then that next lower priority content module is transmitted to the browser program. These steps iterate until insufficient content display area remains to display any added content. This embodiment may also be readily adapted to send all selected content modules during one communication from the Web server to the browser program, instead of during iterative downloads.

As a specific example of the preceding embodiment, a Web designer can assign higher priority to icons than associated text, so that all icons are sent to a cellular telephone before text. Those skilled in the art will recognize that position attributes of the text content are not lost, because absolute or relative position attributes can be assigned separately to the text as well as to the icons. Thus, text would be included in the appropriate locations for larger browser windows, e.g., on a PDA, but not included for small browser windows on smaller client devices such as cellular telephones that don't have enough display area to accom-

modate the lower priority content text. Those skilled in the art will recognize that content can be selectively displayed based on size, or other attributes in addition to, or instead of priority. In any case, icons and/or other content can be selectively downloaded and displayed as a function of the available display or browser window, without requiring a separate Web page document for each different size of client device or different size of browser window. Web clipping, or other proxy server content conversion is not required on the client device, because the content is already prioritized.

Although the present invention has been described in connection with the preferred form of practicing it and modifications thereto, those of ordinary skill in the art will understand that many other modifications can be made to the present invention within the scope of the claims that follow. Accordingly, it is not intended that the scope of the present invention in any way be limited by the above description, but instead be determined entirely by reference to the claims that follow.

The invention in which an exclusive right is claimed is defined by the following:

1. A method for controlling content displayed as a single Web page on a device, where the device is incapable of displaying all available content, comprising the steps of:

(a) automatically determining an available display area for displaying the single Web page on the device;

(b) automatically determining a combination of different portions of the available content that can be fully displayed in the single Web page in the available display area without requiring scrolling in more than one direction and without requiring a modification of the different portions of the content that results in the different portions comprising the combination being perceived in less than their entirety on the single Web page; and

(c) displaying only the combination of different portions of the content that were automatically determined to enable a user to discern all of the information that the combination of different portions of the content provides as fully displayed in the available display area, since the combination of different portions of the content does not employ a hyperlink to display the information it conveys, without requiring scrolling in more than one direction, and without requiring a modification of the combination of different portions of the content that results in the different portions of content comprising the combination being perceived in less than their entirety.

2. The method of claim 1, further comprising the step of dividing the Web page into discrete content modules that are selectively displayable.

3. The method of claim **1**, wherein the step of determining the portion of the content that can be fully displayed in the available display area without requiring scrolling in more than one direction comprises the step of prioritizing different portions of the content based on an order of importance, said different portions of the content corresponding to specific areas of the Web page that are selectively displayed as a function of the available display area.

4. The method of claim **3**, wherein the step of prioritizing comprises the step of ranking the different portions of the content according to their importance in conveying information on the Web page.

5. The method of claim **1**, wherein the step of automatically determining the combination of different portions of the content that can be fully displayed in the available display area without requiring scrolling in more than one direction, comprises the steps of:

(a) detecting a respective share of the available display area required by each portion of the content; and

(b) automatically determining a combination of different portions of the content that are displayable in the display area, based upon the respective share of the display area required by each different portion of the content.

6. The method of claim **5**, wherein the step of automatically determining the combination of different portions of the content comprises at least one of the steps of:

(a) automatically changing a dimension of a portion of the content to fit the dimensions of the available display area;

(b) automatically scaling a portion of the content to fit the available display area;

(c) automatically changing an orientation of a portion of the content to fit the available display area;

(d) automatically converting a portion of the content into a moving image within the available display area; and

(e) automatically subdividing a portion of the content into sub-portions that are displayed sequentially within the available display area.

* * * * *

US006674449B1

(12) **United States Patent**
Banks et al.

(10) **Patent No.: US 6,674,449 B1**
(45) **Date of Patent: Jan. 6, 2004**

(54) **MULTIPLE MODALITY INTERFACE FOR IMAGING SYSTEMS**

(75) Inventors: **Seth R. Banks**, Milwaukee, WI (US); **James K. Cavanaugh**, Chesterton, IN (US); **Thomas M. Hanson**, Waukesha, WI (US); **Linda M. Kohli**, Waukesha, WI (US); **Elizabeth A. Kuhn**, Wauwatosa, WI (US); **David A. Littlejohn**, Wales, WI (US); **Kim M. Ruchti**, Brookfield, WI (US); **Aaron J. Schmidt**, Wales, WI (US); **William M. Stoval**, Menomonee Falls, WI (US)

(73) Assignee: **GE Medical Systems Global Technology Company, LLC**, Waukesha, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/200,056**

(22) Filed: **Nov. 25, 1998**

(51) **Int. Cl.**[7] **G09G 5/00**; G06F 17/60

(52) **U.S. Cl.** **345/740**; 345/625; 345/846; 345/854; 709/5; 709/3

(58) **Field of Search** 345/846, 854, 345/856, 733, 740, 820, 625; 705/5, 3

(56) **References Cited**

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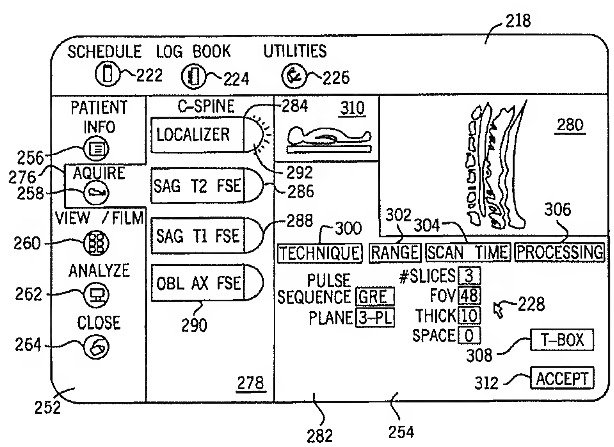
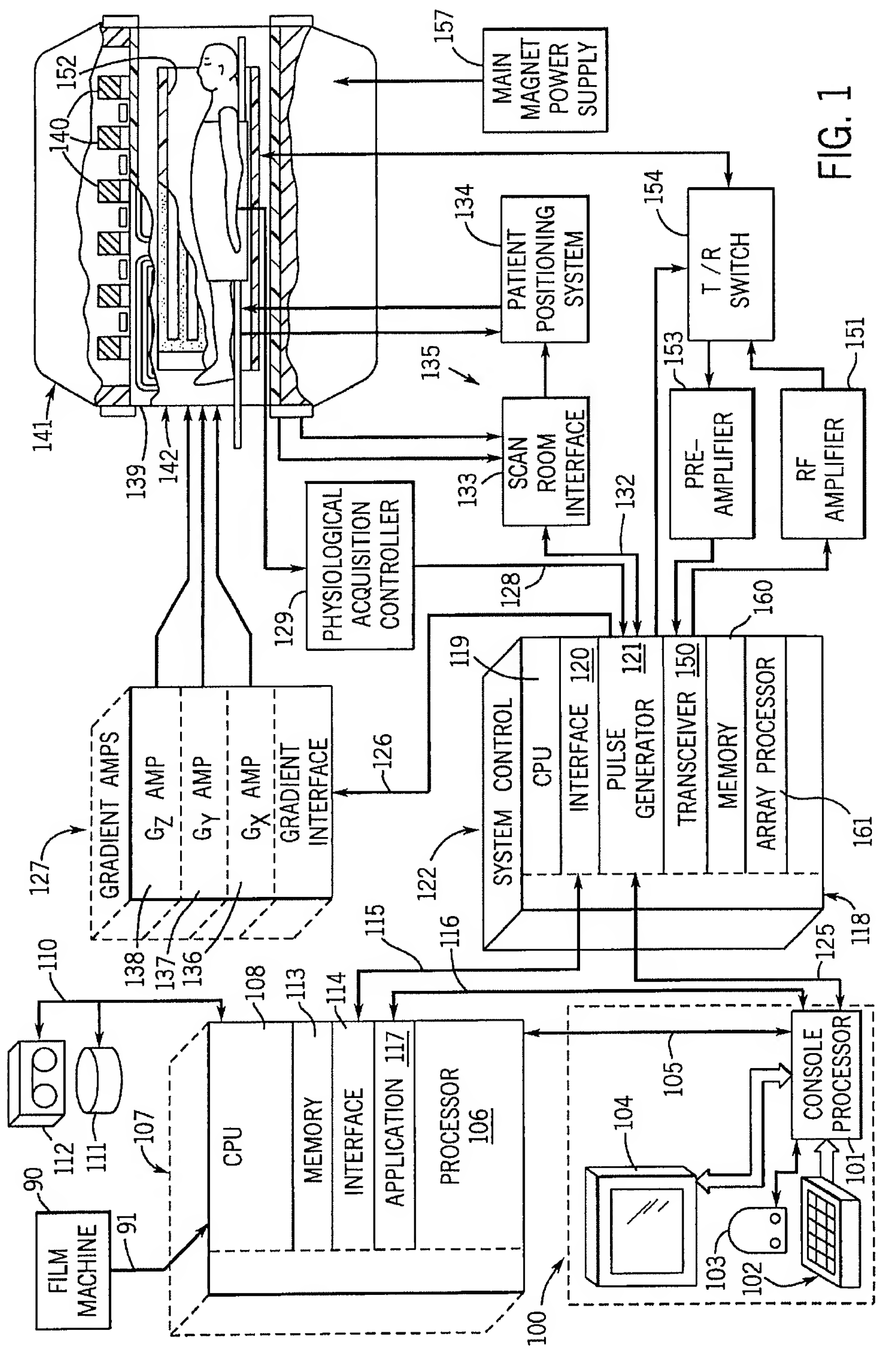
Primary Examiner—Kristine Kincaid
Assistant Examiner—Thomas J Joseph
(74) *Attorney, Agent, or Firm*—Quarles & Brady, LLP; Carl Horton

(57) **ABSTRACT**

A universal interface apparatus for use with any of several different imaging systems for facilitating a plurality of different imaging modalities, the interface including at least function icons in a function navigation space and a workspace, each of the function icons corresponding to a process which is common among all of the imaging modalities, the interface also accessing data tables corresponding to specific workflow protocols for medical facility radiologists and/or for a medical facility in general, the tables identifying function icons and other icons for guiding a technologist through a properly orchestrated imaging process.

25 Claims, 6 Drawing Sheets




MAIN MAGNET POWER SUPPLY
PATIENT POSITIONING SYSTEM
T / R SWITCH
SCAN ROOM INTERFACE
PRE-AMPLIFIER
RF AMPLIFIER
PHYSIOLOGICAL ACQUISITION CONTROLLER
SYSTEM CONTROL
CPU
INTERFACE 120
PULSE GENERATOR 121
TRANSCEIVER 150
MEMORY
ARRAY PROCESSOR
GRADIENT AMPS
G_Z AMP
G_Y AMP
G_X AMP
GRADIENT INTERFACE
FILM MACHINE
CPU
MEMORY
INTERFACE
APPLICATION 117
PROCESSOR 106
CONSOLE PROCESSOR
90
91
100
101
102
103
104
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107
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114
115
116
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153
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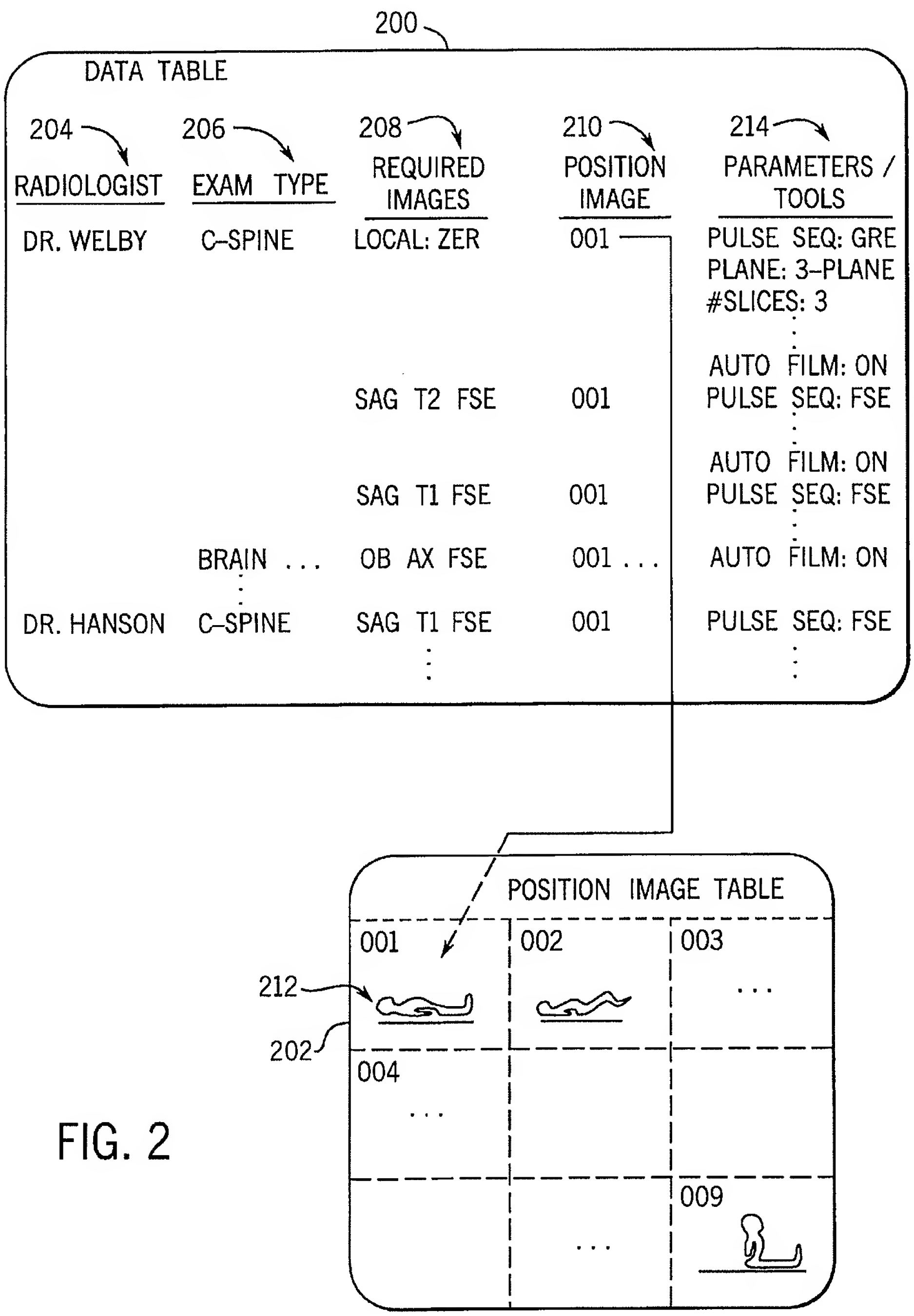
160
161

FIG. 1


200
DATA TABLE
204
206
208
210
214
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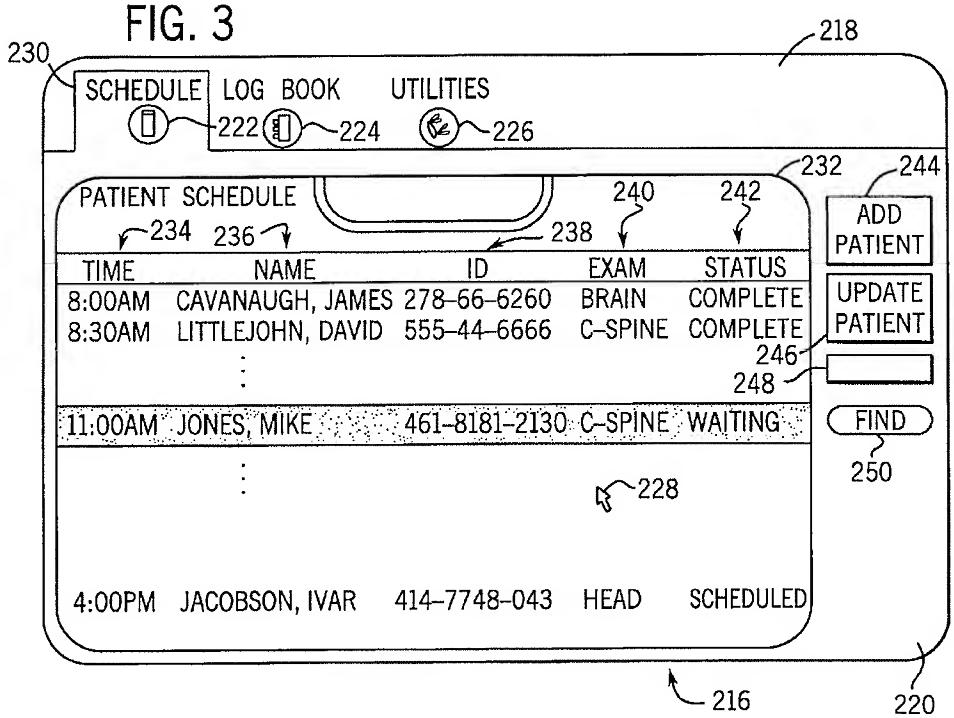
EXAM TYPE
REQUIRED IMAGES
POSITION IMAGE
PARAMETERS / TOOLS
DR. WELBY
C-SPINE
LOCAL: ZER
001
PULSE SEQ: GRE
PLANE: 3-PLANE
#SLICES: 3
AUTO FILM: ON
SAG T2 FSE
001
PULSE SEQ: FSE
AUTO FILM: ON
SAG T1 FSE
001
PULSE SEQ: FSE
BRAIN . . .
OB AX FSE
001 . . .
AUTO FILM: ON
DR. HANSON
C-SPINE
SAG T1 FSE
001
PULSE SEQ: FSE
POSITION IMAGE TABLE
001
002
003
212
202
004
009

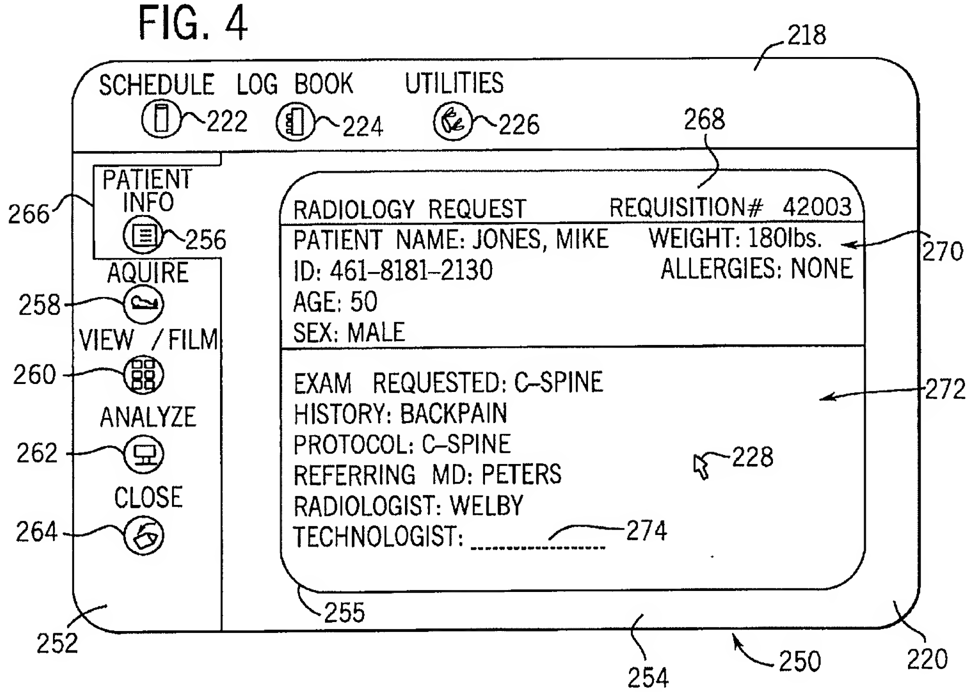
FIG. 2

FIG. 3



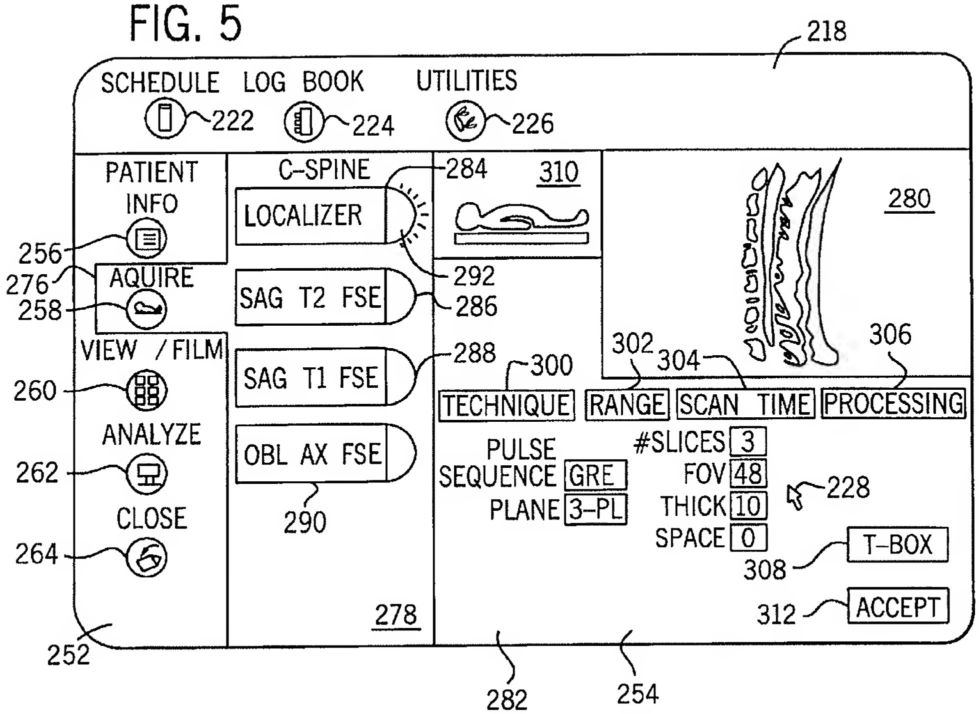
SCHEDULE
LOG BOOK
UTILITIES
PATIENT SCHEDULE
TIME NAME ID EXAM STATUS
8:00AM CAVANAUGH, JAMES 278-66-6260 BRAIN COMPLETE
8:30AM LITTLEJOHN, DAVID 555-44-6666 C-SPINE COMPLETE
11:00AM JONES, MIKE 461-8181-2130 C-SPINE WAITING
4:00PM JACOBSON, IVAR 414-7748-043 HEAD SCHEDULED
ADD PATIENT
UPDATE PATIENT
FIND

FIG. 4



SCHEDULE
LOG BOOK
UTILITIES
PATIENT INFO
AQUIRE
VIEW / FILM
ANALYZE
CLOSE
RADIOLOGY REQUEST
REQUISITION# 42003
PATIENT NAME: JONES, MIKE
WEIGHT: 180lbs.
ID: 461-8181-2130
ALLERGIES: NONE
AGE: 50
SEX: MALE
EXAM REQUESTED: C-SPINE
HISTORY: BACKPAIN
PROTOCOL: C-SPINE
REFERRING MD: PETERS
RADIOLOGIST: WELBY
TECHNOLOGIST:

FIG. 5


SCHEDULE
LOG BOOK
UTILITIES
222
224
226
218
PATIENT INFO
C-SPINE
LOCALIZER
284
310
280
256
276
AQUIRE
258
SAG T2 FSE
292
286
VIEW /FILM
260
SAG T1 FSE
288
300
302
304
306
TECHNIQUE
RANGE
SCAN TIME
PROCESSING
ANALYZE
262
OBL AX FSE
290
PULSE SEQUENCE
GRE
PLANE
3-PL
#SLICES
3
FOV
48
THICK
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SPACE
0
228
T-BOX
308
CLOSE
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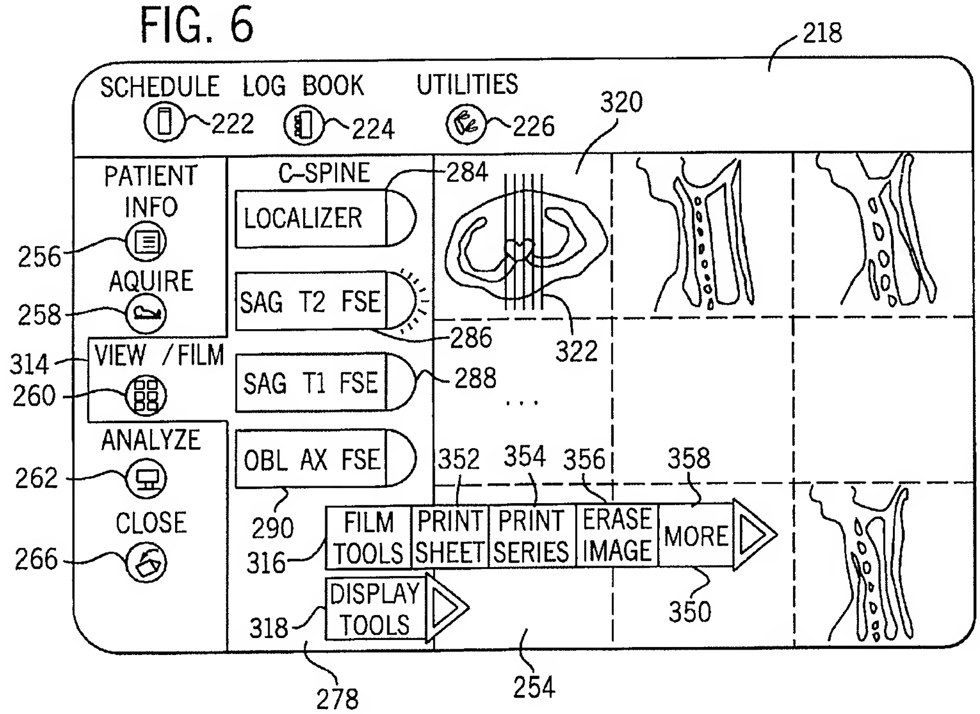
ACCEPT
312
278
252
282
254

FIG. 6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LOG BOOK
UTILITIES
222
224
226
218
320
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LOCALIZER
284
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SAG T2 FSE
286
322
314
VIEW /FILM
260
SAG T1 FSE
288
ANALYZE
262
OBL AX FSE
352
354
356
358
290
CLOSE
266
FILM TOOLS
PRINT SHEET
PRINT SERIES
ERASE IMAGE
MORE
316
350
DISPLAY TOOLS
318
278
254

FIG. 7

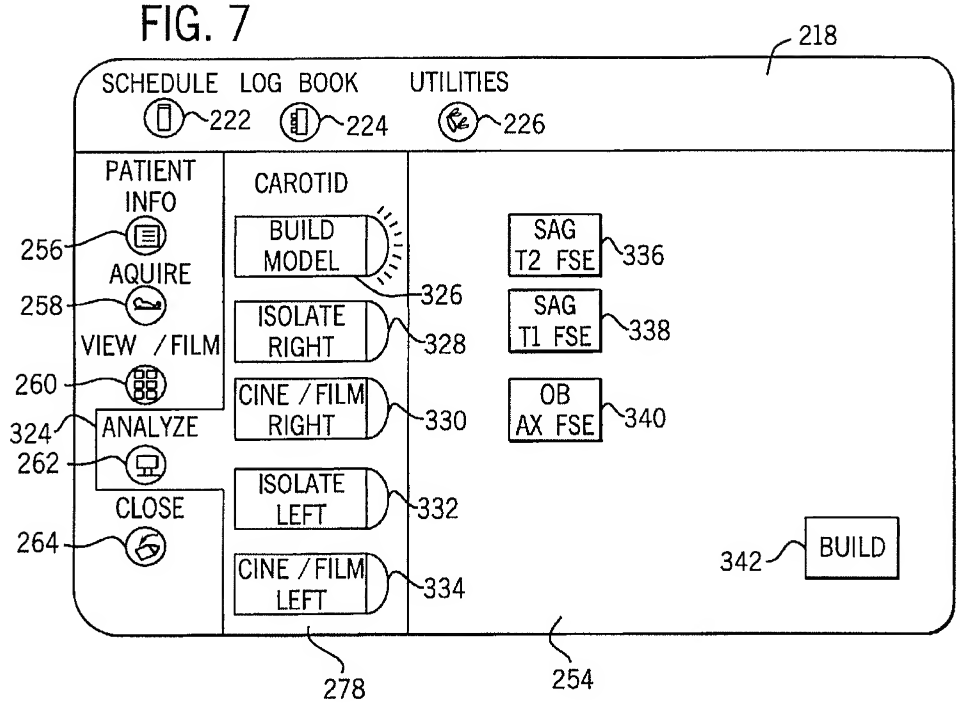

218
SCHEDULE
LOG BOOK
UTILITIES
222
224
226
PATIENT INFO
256
AQUIRE
258
VIEW /FILM
260
324
ANALYZE
262
CLOSE
264
CAROTID
BUILD MODEL
326
ISOLATE RIGHT
328
CINE / FILM RIGHT
330
ISOLATE LEFT
332
CINE / FILM LEFT
334
SAG T2 FSE
336
SAG T1 FSE
338
OB AX FSE
340
342
BUILD
278
254

FIG. 8

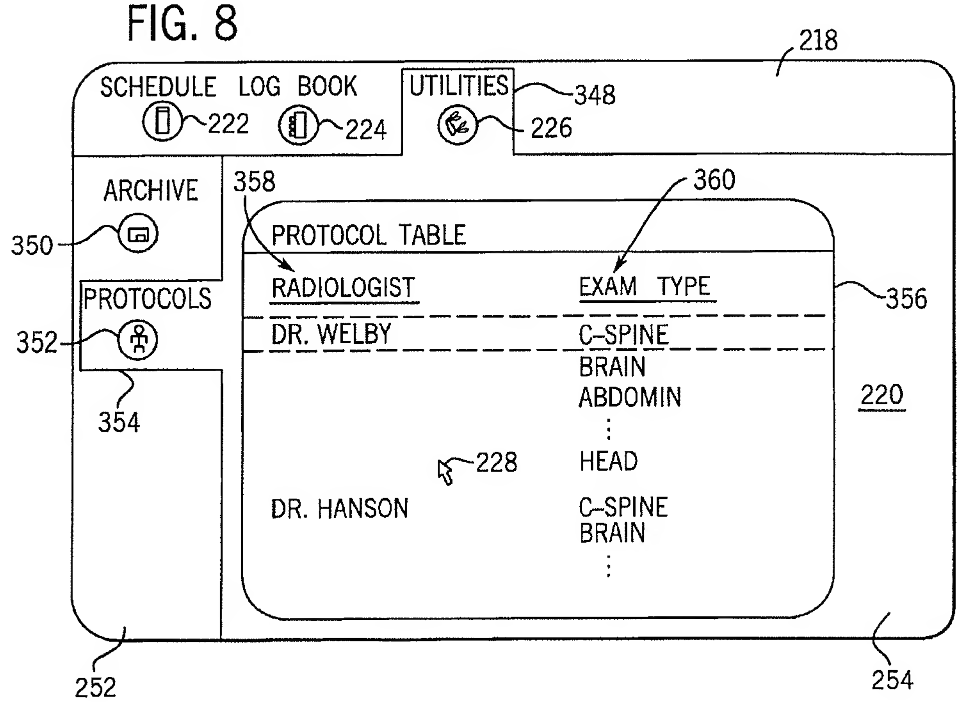

218
SCHEDULE
LOG BOOK
UTILITIES
348
222
224
226
ARCHIVE
350
PROTOCOLS
352
354
358
360
PROTOCOL TABLE
RADIOLOGIST
EXAM TYPE
356
DR. WELBY
C-SPINE
BRAIN
ABDOMIN
220
228
HEAD
DR. HANSON
C-SPINE
BRAIN
252
254

FIG. 9

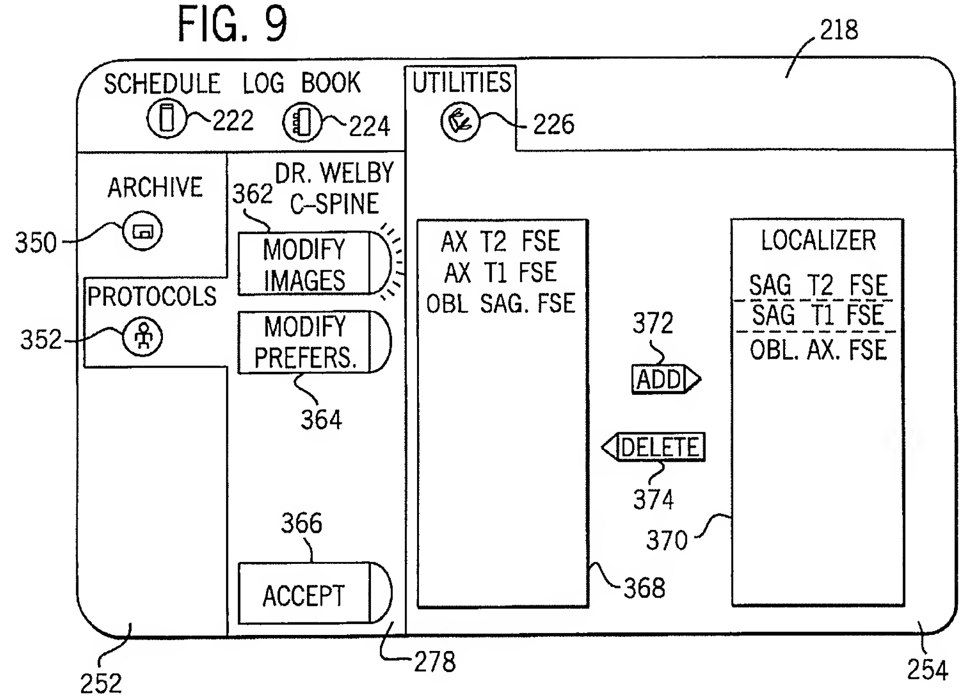
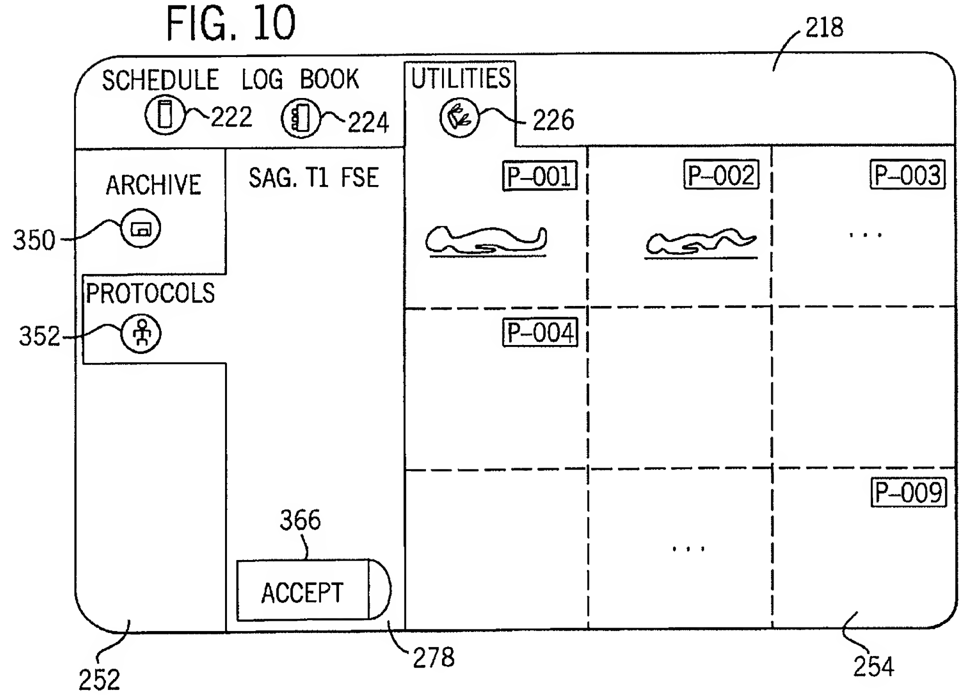

SCHEDULE
LOG BOOK
UTILITIES
218
222
224
226
ARCHIVE
350
PROTOCOLS
352
DR. WELBY
C-SPINE
362
MODIFY IMAGES
MODIFY PREFERS.
364
366
ACCEPT
AX T2 FSE
AX T1 FSE
OBL SAG. FSE
LOCALIZER
SAG T2 FSE
SAG T1 FSE
OBL. AX. FSE
372
ADD
DELETE
374
370
368
252
278
254

FIG. 10


SCHEDULE
LOG BOOK
UTILITIES
218
222
224
226
ARCHIVE
350
PROTOCOLS
352
SAG. T1 FSE
366
ACCEPT
P-001
P-002
P-003
P-004
P-009
252
278
254

MULTIPLE MODALITY INTERFACE FOR IMAGING SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

BACKGROUND OF THE INVENTION

The field of the invention is medical imaging methods and systems. More particularly, the invention relates to a standard system which can be used to interface with any of several different imaging system types.

Traditionally medical facilities have concentrated their efforts on providing the best possible medical services to patients. One area in which the quality of medical services has progressed extremely quickly is in the medical imaging disciplines or modalities which include radiography, fluoroscopy, angiography, magnetic resonance (MR) imaging, ultrasound, nuclear medicine (NM) and computer tomography (CT).

While each of the separate imaging modalities can be used to generate medical images, the medical imaging industry has recognized that each modality is particularly suited for certain imaging techniques and that some modalities are better suited than others for observing specific anatomical phenomenon. For this reason, many medical facilities have acquired a plurality of imaging systems, each of which facilitates a different one of the imaging modalities. This is particularly true in large medical facilities which may have several imaging systems for performing each of the imaging modalities (i.e. several MR systems, several CT systems, etc.). Having several imaging systems each capable of facilitating a different one of the imaging modalities enables a physician to select the best imaging modality for a particular imaging task and therefore increases the usefulness of a resulting image for achieving the particular task. In fact, many medical facilities compete for patients based on the abilities of their medical imaging departments. This imaging department competition places pressure on each medical facility to maintain state of the art imaging departments.

While imaging system quality has increased appreciably, the costs associated with maintaining a state of the art imaging department have also increased appreciably. Unfortunately, despite increased costs associated with providing a state of the art imaging department, recently there has been mounting pressure on many medical facilities to reduce medical costs. For this reasons imaging departments are always looking for ways to decrease department costs while maintaining the highest possible service quality.

In addition to imaging hardware and software costs which are substantial, another expensive component to any successful medical imaging department is imaging personnel which includes radiologists and technologists. A radiologist is a trained physician who specializes in radiology disciplines and typically in other imaging modalities. Technologists are supervised by the radiologists and perform most of the setup, imaging, filming and archiving of images.

Basic training for a technologist in the imaging disciplines typically includes two years of on the job apprenticeship which focuses on the human anatomy and physiology, imaging equipment theory and operation and imaging procedures. In addition to basic training, many technologists obtain additional training in imaging specialties such as ultrasound, NM and radiation therapy. Training in each specialty typically takes about an additional year per specialty. In addition, some technologists obtain further training in sub-specialties such as computer tomography CT, MR and angiography, each of which requires further on the job training. After a successfully completed apprenticeship a technologist performs procedures under the direction of a radiologist.

Because of the differences in the imaging modalities, many medical facilities are staffed with a plurality of technologists, at least one technologist for each imaging modality practiced at the facility. Thus, in some cases a facility may include at lease seven technologists, at least one technologist for each possible modality. While necessary to have a trained technologist in each imaging modality practiced at a facility, such staffing requirements are extremely expensive.

One solution to the excessive technologist staffing problem has been to train technologists in more than a single imaging modality. For example, one technologist may be trained in both NM and CT while another may be trained in fluoroscopy and radiography.

Another solution to the excessive technologist staffing problem has been for medical facilities to share technologists. Thus, for example, a CT technologist may divide her time between three separate medical facilities, every third day spent at a different one of the three facilities.

While both of these solutions reduce costs associated with technologist staffing, each of the solutions is hampered by the current state of imaging systems and the way in which technologists are forced to interact with such systems and system information. An exemplary MR imaging session is instructive in understanding the difficulties associated with training a technologist in more than a single imaging modality.

A typical MR imaging session comprises several different steps including scheduling, analyzing patient information, patient preparation and handling, acquiring image data, displaying images, advanced processing of image data, filming display images, archiving display images, logging completed acquisitions and interpretation and reporting. Each of the different steps often requires a technologist to interact with one or several different department tools. For example, during scheduling a technologist typically uses a scheduling clipboard (i.e. paper on a clipboard) or the like to schedule imaging sessions during the coarse of a day. A scheduling table appears on the board which typically identifies time, patient, the type of exam required (e.g. C-spine, brain, head, etc.), status, identification number, etc.

As an alternative to a hardcopy clipboard, some facilities now have automated scheduling tools whereby a scheduling computer is used to generate a scheduling table which is consulted by the technologist throughout the course of a day to schedule and keep track of required imaging tasks.

In addition to the scheduling table, often a hardcopy (i.e. paper) requisition form will be provided for the technologist which includes additional patient identifying information (e.g. weight, height, sex, etc.), may list allergies, identifies the type of exam (e.g. c-spine, brain, head) to be performed, identifies the requesting physician and so on. Prior to imaging a requisition form is required to ensure that inadvertent imaging is not performed on patients. Once again,

some automated facilities provide a computer for accessing requisition forms.

After examining a requisition form and confirming authorization and prior to meeting a patient, the technologist typically confirms images which have to be acquired during a subsequent session. For example, while imaging a spinal section using the MR modality, it may be conventional to obtain a series of image slices along the length of the spinal section using a T1 FSE pulse sequence and a T2 FSE pulse sequence. In addition, a particular physician may routinely require a third series of image slices using an oblique axial FSE pulse sequence. To confirm required images technologists often consult a required image guidebook which includes lists of required images and may include lists of images specially required by specific radiologists. In addition, a guidebook may also indicate required patient position and equipment position for each required image Moreover, each facility may also have a list of standard required images which must be consulted by the technologist.

During patient preparation and handling, the technologist greets the patient, explains the imaging procedure, helps the patient onto an imaging table and guides the patient into a first position required to collect a first of the required images.

Next, during acquisition the technologist typically uses an acquisition computer to select specific images to be generated by selecting image boundaries and image parameters. To this end the technologist often will acquire one or more localizing images which can be used to generally identify the position of anatomical structures within a patient's body. Viewing the localized image the physician selects required images to be generated and can select imaging parameters to use when generating the required images.

Typically there are many different imaging parameters which can be selected and adjusted. In an effort to make acquisition computers easy to use, many acquisition computers provide an interactive interface including parameter icons for use with a pointing device to enable a technologist to select icons and change parameters with the click of a pointing device button (e.g. a mouse) or via a keyboard. To notify a technologist of all selectable parameters and iconic parameter selecting tools, interfaces of this type display virtually all parameters and associated icons on the interface for examination selection.

In addition, to help a technologist select appropriate parameter settings the imaging guidebook may also include tables indicating standard parameter settings for each image to be formed. These standards may be selected by the facility generally and may also include specific required settings for each requesting radiologist. After selecting parameters the technologist causes the imaging system to acquire the selected images, the system storing the images electronically.

Next, the technologist may reposition the patient in a position optimal for collecting data for the second required image and thereafter follows the same procedure described above to collect required image data.

After required images have been stored electronically the images are downloaded onto an archive system which typically includes a second computer in addition to the acquisition computer. By downloading digital images to a second computer the acquisition computer is freed to perform a subsequent image acquisition. Many acquisition computers enable both archiving and acquisition at the same time so that, while image data corresponding to one patient is downloaded to the second computer, image data corresponding to another patient can be collected. This simultaneous dual function ability increases the throughput rate (i.e. patients/day) for the imaging system and thus overall efficiency.

After the images are downloaded to the second computer, the technologist can use the second computer to analyze the images and perform advanced image processing. Thus, for example, where ten parallel and adjacent MR images have been collected which define a three dimensional data array, a technologist may want to generate a maximum intensity projection (MIP) using three of the ten images. To this end the technologist selects the three images to form the MIP and instructs the second computer to combine the three images to form the MIP. Other advanced processes are possible and are contemplated.

After advanced processing the technologist may select all or a subset of the original or advanced process images for generating film hardcopies for physician review. After selecting images for filming a filming machine, which is also controlled and maintained by the technologist, is used to generate required film pictures. After filming the pictures are provided to a physician for examination and thereafter are archived in a patient's file. In addition to filming, some systems also enable digital archiving so that digital images can be reaccessed using a computer or the like for review or for subsequent advanced processing.

After a completed imaging session the technologist typically uses a binded logbook notebook to document the completed session by indicating the date, time, patient name and number, examination type and so on.

Thus, for a specific modality a technologist has to interact with several specific tools including a schedule, requisition forms, an image guidebook, an acquisition computer, a second advanced processing computer, a filming machine, an archiving database and a logbook.

While learning to use these tools for a single modality is not terribly difficult, differences between similar tools used for different modalities complicates the process of becoming proficient in two or more modalities. Thus, for example, scheduling clipboards for one imaging system may be set up entirely differently than scheduling clipboards for another imaging system. Even where two imaging systems are both automated to include scheduling computers and even where each of the two automated systems are provided by the same vendor, each computer usually includes a different interface such that entry of scheduling information into the two computers is in a unique sequence and different information may be required for each system.

Similarly, each system may have an entirely unique type of equisition form such that locating form information is a tedious task. This is true of both paper forms and automated computerized systems.

Moreover, imaging guidebooks may be relatively complex and can become difficult to use as radiologist's particular requirements are added to the books. For example, at a large medical facility there may be more than 10 radiologists who routinely require MR imaging. While each of the radiologists typically will require some identical images when a specific exam type structure (e.g. c-spine) is performed, many of the radiologists may require additional specific images which the particular radiologist finds helpful during diagnosis. In addition, while, for each required image there might be a typical patient position which is usually used to acquire the image, each radiologist may also have a slightly different preferred position which, in the radiolo-

gist's judgment, yields a slightly better final image. In addition, where radiologist's require specific system parameter settings the technologist also has to consult imaging guidebook tables to determine required settings. Thus, a complete imaging guidebook would have to indicate, for each radiologist, required images for each body structure, where applicable, specific required patient positions for each required image and required parameter settings for each image.

Clearly, using imaging guidebooks is tedious work. Unfortunately, the difficulty of using such guidebooks is exacerbated by the fact that many of the guidebooks have unique forms, some systems include two or more guidebooks and many guidebooks can be supplemented as radiologists are added to or removed from the facility staff.

Moreover, acquisition computer interfaces are often very different and therefore, knowing how to use one interface does not render another interface intuitive. For example, the acquisition computers for a MR system and a CT system often have extremely different interfaces which require a technologist to step through very different protocols. This is not surprising as the parameters which have to be selected for different modalities often are different. However, the tools provided for setting even similar parameters on two different imaging systems often have a very different appearance and different operation. Thus, for example, to increase a displayed parameter value one interface may require a user to place a cursor in a parameter box and type in a desired value. Another interface may include up and down arrow icons adjacent a parameter box with a current parameter setting displayed in the box, the setting increased by selecting the up arrow via a pointing device.

Acquisition computer differences are exacerbated by the fact that most system interfaces are extremely cluttered as virtually every possible tool for setting acquisition parameters is usually provided on the interface screen, this despite the fact that many tools are only rarely used by the technologist. While designed to help a technologist by indicating all possible tools it has been recognized that such a crowded screen actually reduces technologist efficiency as the locations of the most widely used tools are obfuscated.

Furthermore, the interfaces and operation of the advanced processing computers, filming machines and archiving computers for different processes (i.e. modalities) are also often very different.

All of the interfacing problems described above are exacerbated where a single technologist works between facilities as facility unique interfaces, guidebooks and schedules have to be decrypted by visiting technologists prior to efficient system use.

SUMMARY OF THE INVENTION

An exemplary embodiment of the invention includes a universal interface usable with at least first and second different imaging modalities, each modality including functions or procedures which are common to each of the first and second modalities, each separate instance of the interface used with only a specific one of the first or second modalities. The interface comprises a display, a programmed data processor for providing a uniform interface image on the display despite the specific modality, the uniform interface image comprising a function navigation space including function icons corresponding to procedures which are common to both the first and second imaging modalities and a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type

consistent with the specific modality and a pointing device for moving a pointer icon about the display and for selecting displayed icons. When an icon is selected, the processor correlates the selected icon with a corresponding command and executes the command.

The universal interface facilitates fast training of technologists thereby enabling inexpensive cross-modality training and technologist substitution. To this end, it has been recognized that there are several basic system processes which are common to each of the known imaging modalities. The universal interface is structured around the basic processes to provide a feeling of comfort to a technologist proficient in any imaging modality.

It has also been recognized that, for each basic process, there is often a typical sub-process workflow which is routinely followed. Thus, preferably, each procedure which is common to the first and second modalities includes procedure specific sub-processes and the workspace includes a workflow navigation space in which, when a function icon is selected, the processor displays a workflow icon set including a separate workflow icon corresponding to each sub-process of the process associated with the selected function icon and for the specific modality. On each modality interface each of the navigation space and workflow space are similarly positioned and similarly color coded to further render a technologist comfortable using each interface.

Moreover, the invention includes one or more data tables which are accessible by an acquisition computer for guiding a technologist through the process of determining required images and patient positions, setting proper imaging parameters for each required image and selecting desired advanced imaging processes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an MRI system which employs the present invention;

FIG. **2** is a schematic illustrating an exemplary data table and an exemplary position image table according to present invention;

FIG. **3** is a schematic illustrating an exemplary schedule interface screen according to the present invention;

FIG. **4** is a schematic illustrating an exemplary patient information interface screen;

FIG. **5** is a schematic illustrating an exemplary acquire interface screen;

FIG. **6** is a schematic illustrating an exemplary image viewing display screen;

FIG. **7** is a schematic illustrating an exemplary analyze interface screen;

FIG. **8** is a schematic illustrating an exemplary utilities/protocol interface screen;

FIG. **9** is similar to FIG. **8**, albeit illustrating a second level of the protocol interface screen; and

FIG. **10** is similar to FIG. **9** albeit illustrating yet another level of the protocol interface screen.

DESCRIPTION OF THE PREFERRED EMBODIMENT

I. HARDWARE

While the present invention is meant to be used with any imaging system despite the modality facilitated by the system, in order to simplify this explanation the invention

will be described in the context of an exemplary MR system. To this end, referring first to FIG. 1, there is shown the major components of a preferred MR system which incorporates the present invention. The operation of the system is controlled from a universal interface **100** which includes an interface processor **101** that scans a keyboard **102** and receives inputs from a human operator through a display screen **104**. Screen **104** may be either a plasma/touch screen or a more conventional display on which a pointer cursor is provided which can be moved via mouse **103**. For the purposes of the present invention it will be assumed that mouse **103** is used to move a pointing icon or cursor on display **104**.

Interface processor **101** communicates through a communications link **116** with an applications interface module **1 17** in a separate computer system **107**. Through the keyboard **102** and mouse **103**, a technologist controls the production and display of images by a processor **106** in the computer system **107**, which connects to display **104** through a video cable **105** and processor **101**.

Computer system **107** includes a number of modules which communicate with each other through a backplane. In addition to application interface **117** and processor **106**, these include a CPU module **108** which controls the backplane and which connects the computer system **107** through a bus **110** to a set of peripheral devices, including disk storage **111** and tape drive **112**. CPU module **108** is also linked to a film machine **90** via a bus **92**. The computer system **107** also includes a memory module **113**, known in the art as a frame buffer for storing image data arrays, and a serial interface module **114** that links the computer system **107** through a high speed serial link **115** to a system interface module **120** located in a separate system control cabinet **122**.

The system control **122** includes a series of modules which are connected together by a common backplane **118**. The backplane **118** is comprised of a number of bus structures, including a bus structure which is controlled by a CPU module **119**. The serial interface module **120** connects this backplane **118** to the high speed serial link **115**, and pulse generator module **121** connects the backplane **118** to interface **100** through a serial link **125**. It is through this link **125** that the system control **122** receives commands from the technologist which indicate the scan sequence that is to be performed.

The pulse generator module **121** operates the system components to carry out the desired scan sequence. Module **121** produces data which indicates the timing, strength and shape of the RF pulses which are to be produced, and the timing of and length of the data acquisition window. Module **121** also connects through serial link **126** to a set of gradient amplifiers **127** and conveys data thereto which indicates the timing and shape of the gradient pulses that are to be produced during the scan. The pulse generator module **121** also receives patient data through a serial link **128** from a physiological acquisition controller **129**. The physiological acquisition control **129** can receive a signal from a number of different sensors connected to the patient. For example, it may receive ECG signals from electrodes or respiratory signals from a bellows and produces pulses for the pulse generator module **121** that synchronizes the scan with the patient's cardiac cycle or respiratory cycle. And finally, the pulse generator module **121** connects through a serial link **132** to scan room interface circuit **133** which receives signals at inputs **135** from various sensors associated with the position and condition of the patient and the magnet system. It is also through the scan room interface circuit **133** that a patient positioning system **134** receives commands which move the patient cradle and transport the patient to the desired position for the scan.

The gradient waveforms produced by the pulse generator module **121** are applied to a gradient amplifier system **127** comprised of G_x, G_y and G_z, amplifiers **136, 137** and **138**, respectively. Each amplifier **136, 137** and **138** is utilized to excite a corresponding gradient coil in an assembly generally designated **139**. The gradient coil assembly **139** forms part of a magnet assembly **141** which includes a polarizing magnet **140** that produces either a 0.5 or a 1.5 Tesla polarizing field that extends horizontally through a bore **142**. Operation of coils **139** is well known in the art and therefore is not explained here in detail.

Located within the bore **142** is a circular cylindrical whole-body RF coil **152**. This coil **152** produces a circularly polarized RF field in response to RF pulses provided by a transceiver module **150** in the system control cabinet **122**. These pulses are amplified by an RF amplifier **151** and coupled to the RF coil **152** by a transmit/receive switch **154** which forms an integral part of the RF coil assembly. Waveforms and control signals are provided by the pulse generator module **121** and utilized by the transceiver module **150** for RF carrier modulation and mode control. The resulting NMR signals radiated by the excited nuclei in the patient may be sensed by the same RF coil **152** and coupled through the transmit/receive switch **154** to a preamplifier **153**. The amplified NMR signals are demodulated, filtered, and digitized in the receiver section of the transceiver **150**. The transmit/receive switch **154** is controlled by a signal from the pulse generator module **121** to electrically connect the RF amplifier **151** to the coil **152** during the transmit mode and to connect the preamplifier **153** during the receive mode. The transmit/receive switch **154** also enables a separate RF coil (for example, a head coil or surface coil) to be used in either the transmit or receive mode.

The NMR signals picked up by the RF coil **152** are digitized by the transceiver module **150** and transferred to a memory module **160** which is also part of the system control **122**. When the scan is completed and an entire array of data has been acquired in the memory modules **160**, an array processor **161** operates to Fourier transform the data into an array of image data. This image data is conveyed through the serial link **115** to the computer system **107** where it is stored in memory **113**. In response to commands received from interface **100**, this image data may be archived on the tape drive **112** or memory **111**, or it may be further processed by the image processor **106** and conveyed to interface **100** and presented on display **104**.

II. INTERFACE

All of the hardware described above is conventional. The present invention resides within interface **100** and system **107** and is manifest in two general concepts, a universal interface and modality guidance tools which determine information which should be provided to a technologist via the universal interface during an imaging session.

With respect to the universal interface, processes which are common to virtually all imaging modalities have been identified, sub-processes which are common to each process in a specific modality have been identified and parameters which are common to each sub-process in a specific modality have been identified. Based on the common processes, sub-processes and parameters a set of interface screens have been developed which, despite use with each of the modalities, have many identical characteristics which are recognizable and foster a comfortable feeling, even for a technologist using a system for the first time.

With respect to the modality guidance tools, it has been recognized that each hospital, and perhaps each radiologist at a hospital, may require different images to be generated during a specific type of exam, may require specific patient positions during generation of data for certain images and may also require specific parameter settings for each image generated. The modality guidance tools consist of a set of tables stored in computer memory which are used to automatically determine required settings and images and for indicating suitable patient position when a specific radiologist orders an exam of a specific type. After determining required images, positions and parameters using the guidance tools, icons are provided via the universal interface to guide the technologist through a properly orchestrated imaging protocol.

Referring now to FIG. 2, therein are shown two exemplary tables stored in memory **113** which are accessible to processor **106** via the common backplane and which are used by processor **106** to provide interface information to console processor **101** for guiding a technologist through an imaging process. The two tables include a data table **200** and a position image table **202**. Exemplary data table **200** includes five separate types of information. The first type of information includes radiologist indicators which, for the purposes of this explanation are shown as the names of different radiologists in a first table column **204**. While two radiologist names, Dr. Welby and Dr. Hanson are shown, it is contemplated that there may be many more radiologists listed.

A second type of information includes exam types which are shown in a second column **206**. For each doctor listed in first column **204**, every possible type of exam is listed in second column **206**. Exemplary exam types shown in FIG. 2 include a C-spine type and a brain type.

For each exam type listed in the second column **206**, a plurality of required images are listed in a third column **208**. For example, for Dr. Welby's C-spine exam type, required images include a saginal T2 FSE sequence, a saginal T1 FSE sequence and an oblique axial FSE sequence. Although not illustrated, a similar list of required images would be provided for Dr. Welby's brain type examination and for each of the other types of examinations Dr. Welby often requests. In addition, a similar list of required images would be provided for each exam type Dr. Hanson routinely requests and so on.

For each required image in third column **208** a position image address corresponding to an image stored in position image table **202** is provided. For example, for the saginal T2 FSE required image for Dr. Welby's C-spine exam type, the position image address in fourth column **210** is **001**. Address **001** points to an image **212** in position image table **202** which is stored at address **001**. Image **212** shows a patient laying flat on her back with legs extended on an imaging table. It should be noted that while image **212** and other images in position image table **202** are shown as simplified silhouette drawings, more detailed images are contemplated and in fact are preferred with the present invention. The more detailed images may include actual digital pictures of a model positioned in precisely required positions for imaging purposes. In addition, the position images may also include text descriptions of ideal patient positions to help a technologist identify an ideal position. Moreover, while a single position image table is illustrated in FIG. 2, memory **113** (see FIG. 1) may include a separate position image table for each radiologist listed in data table **200**. Furthermore, the position images in table **202** may also indicate desired equipment positions relative to a patient (e.g. location of a CT camera relative a patient).

Referring still to FIG. 2, for each required image in third column **208**, a plurality of tools and default parameter settings for a specific radiologist and specific exam type are listed in fifth column **214**. Importantly the parameters listed in fifth column **214** are only the most important parameters and the most often modified parameters for a particular imaging modality. The tools listed in column **214** are the tools which are necessary for modifying the default parameter values.

It should be appreciated that while the tables shown in FIG. 2 provide data and position images for each radiologist for MR imaging, a separate yet similar table is provided for each of the other six imaging modalities in imaging system memories earmarked specifically for those other modalities. For example, a CT system would include tables similar to table **200** and **202** which identify each radiologist, exam types, required images, position image specifiers and parameters and tool specifiers.

Referring now to FIG. 3, an exemplary interface screen **216** which is provided on display **104** is illustrated. Screen **216** generally includes two spaces including a domain space **218** and a dynamic space **220**. Generally, within domain space **218**, three separate domain icons including a schedule icon **220**, a log book icon **224** and a utility icon **226**, are provided. Each of the domain icons **222**, **224** and **226** can be selected by using mouse **103** (see FIG. 1) to move a pointing cursor or icon **228** about screen **216**. Each of domain icons **222**, **224** and **226** is used to open an entirely different application of the inventive interface system. Generally, schedule icon **222** enables a technologist to review and modify a patient schedule corresponding to a specific imaging system. Log book **224** enables a technologist or radiologist to review a log book of completed imaging sessions and, where images are digitally archived, enables the technologist to retrieve and review the archived images. Utilities icon **226** allow the technologist to perform a number of tasks including, but not limited to, retrieving archived records and modifying the default settings which are illustrated in the tables of FIG. 2.

Initially, when a technologist logs on to interface **100**, the technologist is provided with a simple screen including domain space **218**, dynamic space **220** and the domain icons **222**, **224** and **226** spaced in a single row within domain space **218**. Spaces **218** and **220** are differently colored to easily distinguish there boundaries.

Referring still to FIG. 3, when schedule icon **222** is selected processor **106** accesses a current patient schedule which is stored in memory **113** and performs four separate functions via control processor **101** which are observable on screen **216**. First, processor **106** indicates selection of the schedule icon **222** by providing a "digital tab" **230** which encompasses the schedule icon **222** within dynamic space **220** to distinguish selected icon **222** from the non-selected icons **224** and **226** which remain within domain space **218**. Second, processor **106** displays the current patient schedule on a digital clipboard metaphor image **232**. Metaphor image **232** resembles a conventional hardcopy clipboard which is typically used by technologists to maintain a patient schedule. The schedule on image **232** may include any of several of different types of information, the exemplary schedule of FIG. 3 including a time column **234**, a patient name column **236**, a patient ID column **238**, an exam type column **240** and a status column **242** which indicates whether or not an imaging session has been completed, is in a waiting state or is scheduled for a subsequent time.

Third, processor **106** provides display modifying icons including an add patient icon **244** and an update patient icon

246 which can be used to modify the schedule on image 232. Although not illustrated, it is contemplated that when one of the modify icons 244 or 246 is selected, a window opens up which provides tools to enable a technologist to add, delete or modify information corresponding to any of the information listed on image 232. Methods and software for performing these tasks are well known in the art and therefore are not explained here in detail.

Fourth, processor 106 provides a search box 248 and a find icon 250 which can be used together to locate a specific patient on patient schedule image 232. To this end, a patient's name can be provided in box 248 and thereafter icon 250 can be selected at which time processor 106 searches the table stored in memory 113 and locates the indicated patient.

In addition to the four identified processor functions which are recognizable via display 104, processor 106 also provides a memory 113 address for each patient exam provided on image 232, the memory address invisible to the technologist but nevertheless linked to a specific exam. A specific exam and associated memory address operate like an Internet hyperlink to allow a technologist to access a radiology request form associated with the specific exam and stored at the memory address by selecting the specific exam using icon 228.

Referring to FIGS. 1 and 3, using mouse 103 a technologist can select any of the icons illustrated on screen 216 by placing icon 228 on the illustrated icon and pressing a recognizable sequence of mouse buttons. While schedule image 232 is being examined, a technologist can place pointing cursor 228 on any patient name which appears on image 232 and, by selecting the patient's name, can access a digital radiology request form corresponding to the patient and the specific exam. In particular, prior to every imaging session, a technologist must review a radiology request form to make sure that the imaging session has been authorized by one of the radiologists and to identify any special instructions provided by the radiologist. In FIG. 3, it is assumed that for each exam having a "complete" status, the technologist has already reviewed a radiology request form, met with the patient, set up an exam, performed an imaging session to generate imaging data and has downloaded the imaging data to either of devices 111 or 112. However, for the exams having a "waiting" status indicator in column 242 of image 232, the technologist has not yet accessed a radiology request form.

To access the radiology request form, as indicated above, the technologist uses cursor 228 to select the next exam having a "waiting" status in image 232. In this case, the technologist selected Mike Jones. When selected, the entire row of data in image 232 corresponding to Mike Jones is highlighted. A second selection causes processor 106 to move from a scheduling domain into an imaging session domain.

Referring now to FIG. 4, an interface screen 250 provided by processor 106 when Mike Jones is selected via image 232 is illustrated. Screen 250 includes both the domain space 218 and the dynamic space 220. However dynamic space 220 is now divided into a primary navigation space 252 which, in the exemplary illustration, includes a single column along the left-hand side of dynamic space 220 and a work space 254.

Processor 106 provides a plurality of function icons in navigation space 252. Importantly, the function icons in space 252 have been selected to mirror processor functions which are common to virtually all imaging modalities. Therefore, the navigation space icons can be provided on separate interfaces corresponding to every type of imaging system. Thus, for example, while the interface screen 250 shown in FIG. 4 is specifically for an MR system, an interface having both the domain space 218, including icons, and the navigation space 252, including navigation space icons, would be provided for a CT interface, a radiography interface, a fluoroscopy interface and so on. This feature which clearly defines specific and common functions between all imaging systems fosters a sense of comfort when a technologist moves from one imaging system type to another imaging system type or from one medical facility to another. This common interface also helps guide the technologist through an imaging session.

Referring to FIG. 4, the navigation space icons includes a patient information icon 256, an acquire icon 258, a view/film icon 260, an analyze icon 262 and a close icon 264. It should also be noted that all of the navigation space icons are arranged in a single column which follows a normal workflow pattern from the patient information icon 256 through the acquire icon 258, the view/film icon 260, the analyze icon 262 and the close icon 264. This feature enables a technologist to clearly see a required or desired workflow pattern.

Referring to FIGS. 1, 3 and 4, when a technologist selects Mike Jones on interface 262 processor 106 accesses memory 113 and retrieves the radiology request form which is stored at the address corresponding to the exam for Mike Jones. Retrieving the radiology request form processor 106 displays the request form in workspace 254. In addition, to clearly indicate that the information in workspace 254 is associated with the patient information icon 256, processor 106 encompasses patient information icon 256 in workspace 254 by providing a digital tab 266 which includes patient information icon 265 in workspace 254.

Referring still to FIG. 4, an exemplary radiology request form 255 includes a requisition number 268, patient identification information (e.g. name, id number, age, weight, etc.) generally referenced by numeral 270 and exam request information indicating the type of exam required, relative patient history, a required protocol, the referring doctor, the responsible radiologist and so on, collectively referred to by numeral 272. In addition, processor 106 may include a space 274 where the technologist can input her name to complete the radiology request form. Although not illustrated, iconic tools for modifying the protocol or other request form information may be provided within workspace 254, the tools selectable via pointer icon 228.

After the technologist has examined the radiology request form to determine a required protocol and ensure proper authorization of the exam, the technologist selects acquire icon 258 via icon 228. Referring now to FIG. 5, when acquire icon 258 is selected, processor 106 indicates selection of acquire icon 258 by providing a digital tab 276 which encompasses acquire icon 258 within workspace 254. In addition, processor 106 divides workspace 254 into a workflow navigation space 278, an imaging window 280 and a parameter settings space 282. Workflow navigation space 278 preferably includes a single column adjacent navigation space 252. In the exemplary illustration, the imaging window is in the upper right-hand corner of workspace 254 while parameter settings space 282 encompasses the remainder of workspace 254.

Referring now to FIGS. 1, 2, 4 and 5, in addition to dividing workspace 254 as described above, when acquire icon 258 is selected, processor 106 identifies the radiologist

indicated on the request form **255** and the required protocol from the request form and uses those two pieces of information to access a specific set of required images and parameters in table **200** which is stored in memory **113**. In the present example, processor **106** identifies Dr. Welby and his C-spine protocol as the exam type and accesses memory **113** to identify four required images including a "localizer" a "Sag T2 FSE", a "Sag T1 FSE" and a "ob ax FSE" image. For each of these required images, processor **106** provides a separate icon within space **278**. The icons are identified by numeral **284**, **286**, **288** and **290**, respectively and are collectively referred to as a workflow icon set. Each of the workflow icons includes a virtual button and an LED illustration which, when the icon is selected, lights up. For example, localizer icon **284** includes LED illustration **292**.

Importantly, just as the function icons in navigation space **252** are provided in a typical workflow form from top to bottom, workflow icons in space **278** are also provided in a similar top to bottom workflow pattern. To this end, localizer icon **284** is first listed and therefore generally first selected to generate a "localizer" image in image window **280** which can be used to determine general patient and anatomical body position with respect to system hardware. Thereafter other icons **286**, **288** and **290** are selected to generate three different types of image sets and the typical order is Sag T1 FSE, Sag T2 FSE and ob ax FSE.

Referring to FIGS. **1**, **2** and **5**, initially, when localizer icon **284** is selected, no image is provided in window **280**. However, all of the parameters and tools indicated in the fifth column **214** of table **200** which correspond to the localizer image for Dr. Welby's C-spine type exam are provided in space **282**. All of the parameter values provided are the default values indicated in table **200**. Each of the parameter values can be changed using iconic tools provided in space **282**. For example, to change the pulse sequence of the plane through which a localizer image is taken, a technologist can select a technique tool icon **300** via icon **228**. Although not illustrated, when one of the tool icons such as technique icon **300** is selected, it is contemplated that a window opens up providing tools to modify all of the parameters corresponding to technique (e.g. pulse sequence and plane). Similarly, a range tool icon **302** is provided, a scan tool icon **304** and a processor tool icon **306** each of which, when selected, opens a window for modifying parameters associated therewith.

Referring still to FIGS. **2** and **5**, the parameter values and tools in space **282** are referred to generally as a commonly modified parameter set and associated tools. In addition to displaying all of the parameters values and tools indicated in column **214** of table **200** in space **282**, processor **106** also provides a tool box icon **308** which, when selected, opens another window which includes a relatively large number of additional parameter values and tools which are only seldomly used during localizer imaging. These additional values and tools are referred to generally as a seldomly modified parameter set and associated tools. The idea here is that by providing seldomly used tools in a hidden yet easily accessible format (i.e. "behind" a tool box icon), the screen display is less cluttered and routinely used tools and selected parameters can easily be located. Preferably processor **106** also provides an image position window **310** in space **282** which indicates a patient position via an image from the position image table **202** which is indicated in fourth column **210** of data table **200**. In the present example the displayed image in window **310** is the first image in position image table **202** as indicated in column **210**.

Thus, after selecting localizer icon **284** the technologist can observe the image in window **310** to determine the correct position for the patient and can review all of the default settings for the exam type for the particular radiologist. If the radiologist requested specific parameter values which are different than the default settings, the technologist can use the iconic tools to modify the parameter values. Once the patient is properly positioned and all of the parameter values are properly set, the technologist selects an accept icon **312** indicating to the imaging system that a localizer image should be generated.

Thereafter, a localizer image is generated via the system of FIG. **1** and the image appears in window **280** which is observed by the technologist. If desired, the technologist can generate several different localizer images until patient and anatomical body position is well known.

Next, referring to FIGS. **2** and **5**, after a suitable localizer image has been generated, the technologist selects icon **286** to set up the Sag T2 FSE imaging session and then generates the required image set. Although not illustrated, when icon **286** is selected, processor **106** provides space **282** in a manner similar to that illustrated in FIG. **5**, albeit providing parameter values, tools and a position image window corresponding to the data stored in table **200** which is associated with the Sag T2 FSE required image set. Again, with the parameter values, tools and position image provided in space **282**, the technologist positions the patient accordingly and may modify some of the default parameters prior to selecting the accept icon **312** to generate a series of images corresponding to the desired protocol.

A similar process is performed to generate a series of images for each of the Sag T1 FSE and Ob Ax FSE icons **288**, **290**, respectively. All of the generated images are stored in memory **113**.

Referring now to FIG. **6**, after all of the data or all of the required images has been collected and stored in memory **113**, the technologist selects the view/film icon **260** to review the collected images. When icon **260** is selected, processor **106** indicates selection of icon **260** by providing a digital tab **314** which encompasses icon **260** in workspace **254**. In addition, processor **106** maintains workflow icons **284**, **286**, **288** and **290** in space **278**. Processor **106** also provides film and display tool icons **316** and **318**, respectively, behind which various tools are hidden in window form, the tools described in more detail below.

The technologist can select any of the workflow icons **284**, **286**, **288** or **290** to display corresponding images in space **254**. As illustrated, when icon **286** is selected, an image in a first box **320** includes an axial slice through a patient and provides phantom lines collectively referred to by numeral **322**, each of the lines **322** corresponding to a separate one of the following images displayed in space **254**. Processor **106** divides space **254** equally into a plurality of separate spaces and provides a separate image in each one of the spaces, each image corresponding to a separate one of lines **322**.

After reviewing images, a technologist can use interface **100** to perform advanced processing techniques on the images thereby generating even more informative images for a radiologist to use. To this end, referring to FIG. **7**, a technologist selects analyze icon **262**. Referring also to FIG. **1**, when icon **262** is selected, processor **106** indicates selection of icon **262** by providing a digital tab **324** which extends from workspace **254** and encompasses icon **262**. In the interest of simplifying this explanation, while each separate radiologist at a facility may have a specific set of advanced imaging processes that the radiologist routinely like to have performed, it will be assumed that in this case the protocol

for advanced image processing for each exam type is specified by the facility and is not radiologist dependent. Thus, for a C-spine exam type, the advanced imaging protocol is identical for every radiologist at the facility. While this assumption is made in the interest of simplifying this explanation it should be recognized that a table similar to the table illustrated in FIG. 2 could be provided in memory **113** (see FIG. 1) which would be accessed by processor **106** each time the analyze icon **262** is selected. In this case, the processor **106** would identify radiologist and exam type and access an advanced imaging table to determine a required and radiologist/exam type specific advanced imaging protocol. Thereafter, the processor **106** would provide a workflow icon for each step in the advanced imaging protocol in a workflow navigation space.

In the present example it will be assumed that for a C-spine examination at Dr. Welby's medical facility the standard protocol for all radiologists includes five steps which include, in the order of normal workflow, building a three-dimensional data model, isolating a right artery, rotating and filming the right artery, isolating a left artery and rotating and filming the left artery. To this end, processor **106** provides five workflow icons in workflow navigation space **278**, the icons including a build model icon **326**, an isolate right icon **328**, a cine/film right icon **330**, an isolate left icon **332** and a cine/film left icon **334**.

Referring still to FIG. 7, when the build model icon **326** is selected, processor **106** provides three tool icons **336**, **338** and **340** in work space **254**. Referring also to FIG. 6, icon **336** corresponds to all of the images in the image set associated with the Sag T2 FSE protocol. Similarly, icons **338** and **340** correspond to all of the images associated with the Sag T1 FSE protocol and the Ob Ax FSE protocol, respectively. The technologist selects one of icons **336**, **338** or **340** to identify images which will be used to build the three-dimensional model and thereafter selects a build icon **342** instructing **106** to use the selected image set to build a three-dimensional model.

After the three-dimensional model is generated and stored in memory **113** the technologist steps through each of the isolate right icon **328**, cine/film right icon **330**, isolate left icon **332** and cine/film left icon **334** to select the specific portions of the three-dimensional model for imaging and to generate images of the selected portions. Isolating, rotating and filming are processes which are well known in the art and tools therefore are also well known in the art and therefore those processes and tools are not explained here in detail. It should be sufficient to state that all of the tools and an image display window for performing each of those processes would preferably be provided within space **254**.

Referring once again to FIG. 6, after performing advanced image processing on the images the technologist selects the view/film icon **260** once again to display the original images or the advanced processed images within space **254**. Where advanced processed images have been generated, another workflow icon (not illustrated) would be provided below icon **290** which could be selected by the technologist to view the advanced process images.

Having selected the view/film icon **260**, processor **106** again enables the technologist to select any of the workflow icons **284**, **286**, **288** or **290** to view corresponding images. In FIG. 6 icon **286** has been selected and therefore corresponding images are illustrated. With the images illustrated, the technologist can select display tools icon **318** which opens a window (not illustrated) including a plurality of other tools that allow a technologist to examine displayed images. For example, one of the tools may be a measuring tool which allows a technologist to select two points on an image and measure the distance therebetween. Tools of this nature are well known in the art and therefore are not described here in detail.

In addition, with images displayed, the technologist may select the film tools icon **316** which opens a film tools window **350** as illustrated. Window **350** includes filming tools including a print sheet icon **352**, a print series icon **354** an erase image icon **356** and a more icon **358**. When print sheet icon **352** is selected, processor **106** provides data corresponding to every image in space **252** to film machine **90** and causes film machine **90** to generate either one or a plurality of hardcopy film images of the displayed imaged. When print series icon **354** is selected, processor **106** downloads data corresponding to all images corresponding to all of the workflow icons in space **278** to film machine **90** thereby causing machine **90** to generate hardcopy film images of each corresponding image. To use icon **356**, first a technologist would select one or a plurality of images displayed within space **254** and thereafter select icon **356** to erase the selected image from space **254**. It so contemplated that other filming tools could be accessed by selecting the more icon **358**.

Referring again to FIG. 3, after filming is complete the imaging process is essentially completed for the patient and the process would begin again with the next patient on schedule image **232**.

Referring again to FIGS. 1 and 3, when a technologist selects logbook icon **224**, although not illustrated, processor **106** indicates selection of icon **224** by providing a digital tab which extends from space **220** and encompasses icon **224**. In addition, processor **106** generates a logbook metaphor image (not illustrated) which is similar to the patient's schedule metaphor image **232**, the logbook metaphor image provided in dynamic space **220**. To distinguish the logbook metaphor image from the schedule image **232**, preferably the logbook image has a slightly different appearance. For example, the logbook metaphor image may include a spiral binder appearance along the lefthand edge of the image. Information provided on the logbook image is similar to the information provided on patient schedule image **232** except that the logbook information includes information corresponding to completed imaging sessions. To this end, exemplary logbook image information may include a date, a patient's name, the patient's ID number, an exam type (e.g. brain, head, C-spine, etc.) and a column for indicating whether or not exam images have been archived.

Referring now to FIG. 8, when a technologist selects utilities icon **226**, processor **106** indicates selection by providing a digital tab **348** which extends from space **254** into domain space **218** and encompasses utilities icon **226**. Utilities applications associated with icon **226** may include a number of different functions, two exemplary functions including an archive function and a protocols function which are used to store or retrieve images and to modify data and image tables (see FIG. 2), respectively. To this end, when utilities icon **226** is selected, processor **106** again separates dynamic space **220** into a navigation space **252** and a work space **254**. Processor **106** provides both an archive icon **350** and a protocols icon **352** in space **252**. Each of icons **350** and **352** selectable using icon **228**. When archive icon **350** is selected, processor **106** provides iconic tools within workspace **254** which enable a technologist to retrieve and view archived images corresponding to previously performed imaging sessions. Tools for this purpose are known generally in the art and therefore are not described here in detail.

It is contemplated that a medical facility would likely have a set of internal policies concerning which personnel are authorized to modify default exam protocols and parameter values in data tables like table **200** illustrated in FIG. **2** for semi-permanent storage in memory **113**. For example, one broad rule might be that only a radiologist is authorized to modify her default protocols and parameter values. To enforce such a rule a password security feature may be provided when protocols icon **352** is selected, processor **106** only allowing protocol modification by an authorized radiologist. While a secure system is preferred, it will be assumed that a technologist can modify default protocols and parameter values in table **200** to simplify this explanation.

When a technologist selects icon **352**, processor **106** provides a digital tab **354** which extends from workspace **254** into space **252** and encompasses icon **352**. In addition, processor **106** provides a protocol table **356** which corresponds to data table **200** in FIG. **2**. The exemplary protocol table **356** includes two columns, first column **358** listing facility radiologists identified in table **200** and a second column **360** listing exam types (e.g. C-spine, brain, etc.) routinely requested by a corresponding radiologist. To modify the default settings within table **200**, the technologist uses icon **228** to select a particular radiologist and exam type. For example, a technologist may wish to modify the default settings for Dr. Welby's C-spine exam type. To this end, the technologist selects Dr. Welby's C-spine from table **356**.

Referring now to FIG. **9**, when Dr. Welby's C-spine exam is selected, processor **106** provides a modify images icon **362**, a modify preferences icon **364** and an accept icon **366** in workflow navigation space **278**. In addition, processor **106** provides two tables, a first table **368** indicating additional image types which may be required and a second table **370** indicating already selected required image types for Dr. Welby's C-spine exam. Add and delete icons **372** and **374** are also provided. By selecting an image type in table **368** and then selecting the add icon **372**, the selected image type in table **368** is moved into table **370** and processor **106** updates table **200** to add the selected image type to the data table for future processing. In addition, processor **106** automatically fills in default parameter values and tools in table **200** for the newly selected image type. If desired the default values for the newly selected image type can be modified as explained below. To remove an image type from table **370**, the image type is selected and in table **370** delete icon **374** is selected.

Referring to FIGS. **2** and **9**, to modify a default position image corresponding to Dr. Welby's C-spine exam, the technologist selects one of the image types in table **370** and thereafter selects modify images icon **362**. Referring also to FIG. **10**, when the modify images icon **362** is selected, processor **106** divides space **254** into a plurality of spaces and provides a separate position image in each of the plurality of spaces. In FIG. **10**, space **254** is divided into nine separate spaces and therefore nine separate position images are provided. Since additional position images are possible, additional screens may be accessed via a scrolling tool (not illustrated) in space **254**. Preferably, a position image is provided for each image in position image table **202** in FIG. **2**. A separate selection icon (i.e. P-**001**, P-**002**, etc.) Is provided for each displayed image. The technologist can select any of the position images illustrated in space **254** via icon **228** and a properly selected icon P-**001**, P-**002**, etc. After selecting an image, the technologist selects the accept icon **366** at which point processor **106** updates data table **200** to indicate the selected position image in column **210**. Thereafter, processor **106** regenerates the screen illustrated in FIG. **9**.

Referring again to FIGS. **2** and **9**, to modify the preferences and tools in column **214** of table **200**, a technologist selects modify preferences icon **364**. Although not illustrated, when icon **364** is selected, processor **106** indicates all parameter values in space **254** and provides suitable iconic tools for modifying the parameter values. Once the parameter values have been set, the technologist again accepts the values by selecting an icon similar to accept icon **366** which returns the technologist back to the screen illustrated in FIG. **9**.

Referring still to FIGS. **2** and **9**, to accept all of the changes made to table **200**, the technologist selects accept icon **366** once again at which point processor **106** provides the screen illustrated in FIG. **8**. Other modifications to protocols can be made in a similar fashion.

It should be appreciated that the above-described interface can be used to simplify technologist training thereby enabling less expensive technologist cross-training between imaging system modalities and enabling interfacility technologist substitution with relatively little difficulty. The guidance tools which consist primarily of guidance tables similar to those illustrated in FIG. **2** and an easily understood workflow which is presented in function and workflow icons through the inventive universal interface enable easy cross-training and interfacility substitutions.

To apprise the public of the scope of this invention, we make the following claims.

What is claimed is:

1. A medical image data acquisition system interface usable with at least first and second different medical imaging data acquisition systems that include first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each modality including functions which are common to each of the first and second modalities, each separate instance of the interface used with only a specific one of the first or second modality systems and linked to a diagnostic system for acquiring data according to the specific one of the first and second acquisition modalities, the interface comprising:

a display;

a programmed data processor for providing a uniform interface image on the display despite the specific data acquisition modality associated with the diagnostic system linked to the interface, the uniform interface image comprising:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality, wherein the workspace includes a workflow navigation space in which, when a function icon is selected, the processor displays a workflow icons

set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality; and

a pointing device for moving a pointer icon about the display and for selecting displayed icons;

wherein, when an icon is selected, the processor correlates the selected icon with a corresponding data acquisition command and executes the command; and

wherein each subprocess includes subprocess specific parameters, the workspace includes both an imaging window and a parameter setting space adjacent the imaging window and, when a workflow icon is selected, the processor displays a parameter value set and setting icons in the setting space which correspond to the subprocess specific parameters associated with the selected workflow icon, each parameter value indicating the current parameter value, the setting icons useable to modify the current parameter values.

2. The interface of claim **1** wherein functions corresponding to each specific one of the medical image data acquisition modalities are typically performed in an exemplary workflow pattern including a series of sequential steps and the function icons are arranged in an order of the exemplary workflow pattern.

3. The interface of claim **2** wherein the function icons are arranged in a single column.

4. The interface of claim **2** wherein the function icons include a patient information icon and an acquire icon.

5. The interface of claim **4** wherein the function icons also include a view/film icon, an analyze icon and a close icon.

6. The interface of claim **1** wherein the subprocesses of each procedure typically are performed in an exemplary workflow pattern including a series of consecutive steps and the workflow icons are arranged in an order of the exemplary workflow pattern.

7. The interface of claim **6**, wherein the workflow icons are arranged in a single column.

8. The interface of claim **1** wherein the workflow icons include a setup icon which corresponds to the process of positioning a patient for imaging, when the setup icon is selected, the processor providing a position window in the workspace and providing an image of a properly positioned patient in the position window.

9. Interface of claim **1** wherein subprocess parameters corresponding to each subprocess include a commonly modified parameter subset and a seldomly modified parameter subset and wherein, when a workflow icon is selected the processor displays parameter values and setting icons which correspond to the commonly modified parameter subset and a toolbox icon, when the toolbox icon is selected, the processor opening a toolbox window and displaying the parameter values and setting icons which correspond to the seldomly modified parameter set.

10. The interface of claim **1** wherein a plurality of physicians may prescribe imaging using the specific modality and each physician may have different initial current parameter value settings for each subprocess, the processor storing a table which correlates each physician with physician specific initial current parameter value settings, a physician identifier provided to the processor and, when a specific workflow icon is selected, the processor accesses the table, correlates the physician identifier with the selected subprocess initial current parameter value settings and provides parameter icons indicating the initial current parameter value settings.

11. The interface of claim **1** wherein, in addition to the navigation space and the workspace, the processor also provides a domain space and a schedule icon in the domain space and wherein, when the schedule con is selected, the processor clears the workspace and navigation space and therein provides a schedule metaphor image which includes imaging system scheduling information.

12. The interface of claim **1** wherein, in addition to the navigation space and the workspace, the processor also provides a domain space and a logbook icon in the domain space and wherein, when the logbook icon is selected, the processor clears the workspace and navigation space and therein provides a logbook metaphor image which includes imaging system logbook information.

13. The interface of claim **1** wherein the system is also an image manipulation system.

14. A medical image data acquisition system interface usable with at least first and second different medical imaging data acquisition systems that include first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each modality including functions which are common to each of the first and second modalities, each separate instance of the interface used with only a specific one of the first or second modality systems and linked to a diagnostic system for acquiring data according to the specific one of the first and second acquisition modalities, the interface comprising:

a display;

a programmed data processor for providing a uniform interface image on the display despite the specific data acquisition modality associated with the diagnostic system linked to the interface, the uniform interface image comprising:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality, wherein the workspace includes a workflow navigation space in which, when a function icon is selected, the processor displays a workflow icons set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality; and

a pointing device for moving a pointer icon about the display and for selecting displayed icons;

wherein, when an icon is selected, the processor correlates the selected icon with a corresponding data acquisition command and executes the command; and

wherein the processor stores a workflow table which correlates subprocess sets with each modality function and wherein the processor provides a protocols icon which, when selected, causes the processor to display icons in the workspace for modifying the subprocess set to provide a modified subprocess set

which is then stored by the processor as the subprocess set, the next time the corresponding function icon is selected, the processor providing a workflow icon for each of the subprocesses in the subprocess set.

15. A medical image data acquisition system interface usable with at least first and second different medical imaging data acquisition systems that include first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each modality including functions which are common to each of the first and second modalities, each separate instance of the interface used with only a specific one of the first or second modality systems and linked to a diagnostic system for acquiring data according to the specific one of the first and second acquisition modalities, the interface comprising:

a display;

a programmed data processor for providing a uniform interface image on the display despite the specific data acquisition modality associated with the diagnostic system linked to the interface, the uniform interface image comprising:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality, wherein the workspace includes a workflow navigation space in which, when a function icon is selected, the processor displays a workflow icons set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality; and

a pointing device for moving a pointer icon about the display and for selecting displayed icons;

wherein, when an icon is selected, the processor correlates the selected icon with a corresponding data acquisition command and executes the command; and

wherein a plurality of physicians may prescribe imaging using the specific modality and each physician may have a different subprocess procedure for modality functions, the processor storing a table which correlates each physician with a physician specific subprocess set for each function, a physician identifier provided to the processor and, when a specific function icon Is selected, the processor accesses the table, correlates the physician identifier with selected function subprocess set and provides a workflow icon for each subprocess in the subprocess set.

16. A method for use with a specific one of at least first and second imaging systems, the first and second systems including first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each system also including a processor linked to the acquisition hardware, a display and a pointing device for moving a pointer icon about the display and for selecting displayed icons, the method for guiding a technologist through the processes required to use a modality specific acquisition system, the method comprising the steps of:

providing an interface image on the display including:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality;

providing a pointer icon on the display;

when the pointer icons is used to select one of the function icons, correlating the selected icon with a corresponding data acquisition command and executes the command,

wherein the step of providing an interface image includes the step of, as part of the workspace, providing a workflow navigation space and, when a function icon is selected, the method further includes the step of displaying a workflow icon set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality in the workflow navigation space; and

wherein each subprocess includes subprocess specific parameters, the step of providing an interface image includes the step of, as part of the workspace, providing both an imaging window and a parameter setting space adjacent the imaging window and, when a workflow icon is selected, the method further includes the steps of, displaying a parameter value set and setting icons in the setting space which correspond to the subprocess specific parameters associated with the selected workflow icon, each parameter value indicating the current parameter value, the setting icons useable to modify the current parameter values.

17. The method of claim **16** wherein functions corresponding to each specific one of the medical image data acquisition modalities are typically performed in an exemplary workflow pattern including a series of sequential steps and the function icons are arranged in an order of the exemplary workflow pattern.

18. The method of claim **17** wherein the function icons are arranged in a single column.

19. The method of claim **16** wherein the subprocesses of each procedure typically are performed in an exemplary workflow pattern including a series of consecutive steps and the workflow icons are arranged in the workflow navigation space in an order of the exemplary workflow pattern.

20. The method of claim **16** wherein a plurality of physicians may prescribe imaging using the specific modality and each physician may have different initial current parameter value settings for each subprocess, the processor storing a table which correlates each physician with physi-

cian specific initial current parameter value settings, the method further including the steps of receiving a physician identifier, when a specific workflow icon is selected, accessing the table, correlating the physician identifier with the selected subprocess initial current parameter value settings and providing parameter icons indicating the initial current parameter value settings.

21. The method of claim **16** wherein the system is also an image manipulation system.

22. A method for use with a specific one of at least first and second imaging systems, the first and second systems including first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each system also including a processor linked to the acquisition hardware, a display and a pointing device for moving a pointer icon about the display and for selecting displayed icons, the method for guiding a technologist through the processes required to use a modality specific acquisition system, the method comprising the steps of:

providing an interface image on the display including:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality;

providing a pointer icon on the display;

when the pointer icons is used to select one of the function icons, correlating the selected icon with a corresponding data acquisition command and executes the command,

wherein the step of providing an interface image includes the step of, as part of the workspace, providing a workflow navigation space and, when a function icon is selected, the method further includes the step of displaying a workflow icon set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality in the workflow navigation space; and

wherein the workflow icons include a setup icon which corresponds to the process of positioning a patient for imaging, when the setup icon is selected, the method further including the step of providing a position window in the workspace and providing an image of a properly positioned patient in the position window.

23. A method for use with a specific one of at least first and second imaging systems, the first and second systems including first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each system also including a processor linked to the acquisition hardware, a display and a pointing device for moving a pointer icon about the display and for selecting displayed icons, the method for guiding a technologist through the processes required to use a modality specific acquisition system, the method comprising the steps of:

providing an interface image on the display including:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality;

providing a pointer icon on the display;

when the pointer icons is used to select one of the function icons, correlating the selected icon with a corresponding data acquisition command and executes the command,

wherein the step of providing an interface image includes the step of, as part of the workspace, providing a workflow navigation space and, when a function icon is selected, the method further includes the step of displaying a workflow icon set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality in the workflow navigation space; and

wherein subprocess parameters corresponding to each subprocess include a commonly modified parameter subset and a seldomly modified parameter subset and wherein, when a workflow icon is selected the step of displaying parameter values includes the step of displaying parameter values and setting icons which correspond to the commonly modified parameter subset and a toolbox icon and, when the toolbox icon is selected, the method further includes the step of opening a toolbox window and displaying the parameter values and setting icons which correspond to the seldomly modified parameter set.

24. A method for use with a specific one of at least first and second imaging systems, the first and second systems including first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each system also including a processor linked to the acquisition hardware, a display and a pointing device for moving a pointer icon about the display and for selecting displayed icons, the method for guiding a technologist through the processes required to use a modality specific acquisition system, the method comprising the steps of:

providing an interface image on the display including:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality;

providing a pointer icon on the display;

when the pointer icons is used to select one of the function icons, correlating the selected icon with a corresponding data acquisition command and executes the command,

wherein the step of providing an interface image includes the step of, as part of the workspace, providing a workflow navigation space and, when a function icon is selected, the method further includes the step of displaying a workflow icon set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality in the workflow navigation space; and

wherein the processor stores a workflow table which correlates subprocess sets with each modality function and wherein the method further includes the steps of displaying a protocols icon, when the protocols icon is selected, displaying icons in the workspace for modifying the subprocess set to provide a modified subprocess set, storing the modified subprocess set as the subprocess set and, the next time the corresponding function icon is selected, providing a workflow icon for each of the subprocesses in the subprocess set.

25. A method for use with a specific one of at least first and second imaging systems, the first and second systems including first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each system also including a processor linked to the acquisition hardware, a display and a pointing device for moving a pointer icon about the display and for selecting displayed icons, the method for guiding a technologist through the processes required to use a modality specific acquisition system, the method comprising the steps of:

providing an interface image on the display including:

a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses; and

a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality;

providing a pointer icon on the display;

when the pointer icons is used to select one of the function icons, correlating the selected icon with a corresponding data acquisition command and executes the command,

wherein the step of providing an interface image includes the step of, as part of the workspace, providing a workflow navigation space and, when a function icon is selected, the method further includes the step of displaying a workflow icon set including a separate workflow icon corresponding to each subprocess of the process associated with the selected function icon and for the specific modality in the workflow navigation space; and

wherein a plurality of physicians may prescribe imaging using the specific modality and each physician may have a different subprocess procedure for modality functions, the processor storing a table which correlates each physician with a physician specific subprocess set for each function, the method further including the steps of receiving a physician identifier and, when a specific function icon is selected, accessing the table, correlating the physician identifier with the selected function subprocess set and providing a workflow icon for each subprocess in the subprocess set.

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